THURSDAY, OCTOBER 11, 1894.

ASTRONOMICAL SPECTROSCOPY.

A Treatise on Astronomical Spectroscopy. A translation of Dr. J. Scheiner's "Die Spectralanalyse der Gestirne." Translated, revised, and enlarged by E. B. Frost, M.A. xiii. + 482 pp. 8vo., 81 woodcuts, 2 plates. (Boston and London: Ginn and Co., 1894.)

THE German original of this work appeared in the autumn of 1890, and was doubtless eagerly welcomed by many who had felt the want of a handbook of spectroscopy which gave a tolerably detailed account of the vast amount of work accumulated during the last twenty-five years. From the position of the author in the Astrophysical Observatory at Potsdam, it was to be expected that the subject would be treated in a scientific spirit, and that he would not merely produce a popular book, but one which would be of real use to students of the youngest branch of astronomy. These expectations were to a great extent fulfilled, although it must have been felt by many readers outside Germany that the book suffered from the same defect as Secchi's "Le Soleil," that of frequently giving undue prominence to the researches made at the observatory where the author was working.

The English edition now before us is not a mere translation. Not only has it been brought up to date by the addition of the results of observations published since 1890, and in some cases even by the insertion of results of American work not yet published elsewhere, but Prof. Frost has evidently been anxious to be more fair in dealing with older work of non-German astronomers, and to bear in mind that all spectroscopic researches do not bear the stamp, "Made in Germany." No attempt has been made to distinguish the portions so added from the original text, except in a few cases where Dr. Scheiner requested it, and where the additional matter is put in brackets. At the end of the preface Dr. Scheiner has inserted a number of notes on various points, as to which he differs from the views of the translator.

The first part (110 pp.) deals with "Spectroscopic Apparatus," beginning with the effect of imperfect achromatism of the telescope objective on the spectrum, and the means it furnishes of testing the achromatism of an object-glass. Harkness, Vogel, and Young have applied this method in various ways; but it may be mentioned here that the method is much older, and has been used by d'Arrest and others. The next paragraphs discuss the passage of light through prisms and prism-systems, the loss of light by reflection and absorption, the curvature of the spectral lines, the properties of the cylindrical lens, and the effect of atmospheric disturbances on spectroscopic observations. A lengthy account follows of all the various spectroscopes and spectrometers which have been brought into use from about the year 1817 (not 1823), when Fraunhofer designed the objective-prism spectroscope, and down to the present day, the theories and modes of adjustment of the instruments being fully considered. The translator has here added accounts of Rowland's construction and use of concave gratings, and of Michelson's and Morley's application of interference methods to spectroscopic measurements; he might also in this chapter have inserted a description of the bolometric methods of observation, which have yielded such splendid results (they are partly mentioned in the chapter on the sun, but the instrumental arrangements should have been given in detail). In the paragraph on photographic spectra the Potsdam spectrograph is chiefly considered, but the translator also describes Hale's spectroheliograph.

The second part of the book (pp. 111–150) on "Spectroscopic Theories" is divided into two chapters on Kirchhoff's Law of the ratio between the absorptive and emissive power, and on Doppler's principle. Prof. Frost states in the preface, that in view of the contradictory results of recent investigations upon the emission of light by gases, he has not thought it wise to make any additions to the chapter on Kirchhoff's Law. It seems, however, strange that he should not have drawn attention to these investigations, and pointed out their immense importance for the interpretation of celestial spectroscopic observations, though a careful reader will not fail to see, even from the short account given of E. Wiedemann's researches, how great a *rôle* "luminescence" phenomena are likely to play in future theories of the nature of celestial bodies. The chapter on Doppler's principle deals fully with the theoretical aspect of this important matter and the various objections which have been raised from time to time, while the splendid practical results are deferred to a chapter at the end of the book.

The third and largest part (pp. 151–360) is devoted to the "Results of Spectroscopic Observations." In the German original all wave-lengths were based on the Potsdam system of Müller and Kempf, and were expressed in millionths of a millimetre, but the translator has reduced them all to Rowland's system of 1893, and has adopted the tenth-metre as his unit, in accordance with the practice of most British and American spectroscopists. The chapter on the sun describes first the various methods of investigating the ultra-red spectrum, and includes an account of Langley's unpublished method. By this the invisible spectrum is moved by clockwork across a bolometer strip, the passage of the lines being recorded by a sensitive reflecting galvanometer, the point of light from which falls on a photographic film, also moved synchronously by clockwork in a direction at right angles to the plane of the mirror's movement, thus automatically producing an energy curve. This is subsequently converted into a linear spectrum containing dark lines corresponding to the cold spaces in the invisible spectrum. The ultra-violet spectrum is next shortly described, and lists of elements present in the sun are given. In the paragraph on the atmospheric lines, the translator has substituted Cornu's list of these for those of Ångström and Vogel, which Dr. Scheiner had preferred; but we miss references to Dr. L. Becker's investigation of the low-sun spectrum and (curiously enough) to Dr. Müller's spectroscopic observations on the Säntis, although the latter were published more than a year and a half ago in the Potsdam publications. More remarkable than these omissions is, however, the brevity with which the spectra of sun-spots, faculæ, and the chromosphere are treated in only twenty-

one pages. In the preface, the author accounts for this by pointing out that the present state of our knowledge of the constitution of the sun is unsatisfactory, and that we have "a large mass of observational data, although for the most part unscientifically discussed; and on the other hand, an indefinite number of hypotheses and solar theories, which are, with few exceptions, radically wrong at the start, and often contradictory to the most simple physical views of to-day." He therefore felt unwilling to undertake the task of discussing and sifting these theories. No doubt an author has a perfect right to decline an uncongenial task, but it certainly detracts from the value of the book that it gives comparatively scant information about our central luminary, on which spectroscopists have spent so much labour; and in the succeeding chapters Dr. Scheiner has by no means been adverse to dealing with "hypotheses and theories." It is, of course, as impossible to discuss the results of spectroscopic observations without attempting to interpret them, as it was for our forefathers three hundred years ago to discuss the motions of the planets "without any hypothesis." And notwithstanding his caution, the author has not been able to keep clear of questionable hypotheses on matters connected with the sun, as when he, for instance, suggests that the unsymmetrical broadening of lines in spot-spectra might arise from the metals entering into combinations with the metalloids. This idea is also afterwards brought in to account for the same phenomenon in star-spectra of Type III*a*, but Dr. Scheiner seems lately to have abandoned it, as he in a note to p. 308 concludes from recent observations that the unsymmetrical broadening is due to accidental "clustering" of fine lines. With regard to the spectra of sun-spots, we notice that all the work done at South Kensington is completely ignored.

While the chapter on the spectra of the planets, as to which not much work has been done of late years, is naturally somewhat meagre, that on comets is very full and interesting, and includes an account of the important laboratory work of Hasselberg. The evident dependence of the spectrum on the distance of a comet from the sun is duly emphasised, but the account of the two most remarkable comets of 1882 might have been more lengthy, as we, for instance, do not find any reference to the dark absorption lines seen with more or less certainty by several observers, and which (if really existing) are of very great importance for the interpretation of the changes in the heads of comets about the time of perihelion passage.

In the chapter on Nebulæ, a complete list of gaseous nebulæ is given, as well as one of the minute planetary nebulæ found with the spectroscope by Pickering and Copeland, and it is interesting to see how this latter class of objects, like the older gaseous nebulæ, cling to the Milky Way. A list is also given of all the lines observed in the spectra of nebulæ. It might have been mentioned that the line at 4472 (which also occurs in some stars of Type I*a* and in Nova Aurigæ) is probably identical with a well-known chromospheric line, associated with D_3 and the hydrogen lines, as suggested by Mr. Lockyer. The author does not express any opinion as to whether the temperature of nebulæ is high or low, but he remarks that the comparative simplicity of the spectrum points to the conclusion that the density of these bodies is extremely low.

In the lengthy chapter on the spectra of the stars, the classification of Vogel is followed, apparently somewhat reluctantly on the part of the translator. So long as the system is not supposed to represent the gradual evolution of a star, there can, of course, be no objection to it; but in the light of the results obtained from temporary stars, and the detection of dark lines in spectra of Type I*c*, it certainly looks doubtful if the bright line stars can properly be divided among the two first classes (I*c* and II*b*).

The account of spectra of Type I*a* includes a list of ninety-one lines measured by the author in the photographic spectrum of Sirius, and an account of the harmonic relations between the hydrogen lines. That the stars of this class are the hottest of all, is generally conceded, and the confirmation of this view, which Dr. Scheiner (in a note on p. vii.) finds in the appearance of the magnesium line at 4481, was indeed found many years ago by Mr. Lockyer (*Proc. R.S.* xxx. p. 29), who first called attention to the fact that this line can only be produced by a high tension spark, and is indicative of very high temperature. In the spectrum of α Cygni (Type I*b*) it is the strongest of all lines. Notwithstanding this the author concludes from the fact that only the fainter iron lines occur, that a very different temperature must prevail in stars of Type I*b* from that in stars of I*a*. Yet the possibility does not seem to be excluded that this may arise from different conditions as to density. Under the heading "Spectra of Type I*c*," the translator gives a detailed account of Belopolsky's investigation of β Lyræ, with regard to which Dr. Scheiner remarks in a note that, in view of recent observations made at Potsdam, he cannot believe the phenomenon to be nearly as simple as Belopolsky's observations would indicate. "There is great probability that more than two bodies are concerned in the case of β Lyræ."

Passing to the Type II*a*, we find a catalogue of 290 lines measured by the author on Potsdam photographs of the spectrum of α Aurigæ. While the author justly considers this a complete proof of the absolute agreement between the spectrum of this star and that of the sun, he takes a very pessimistic view of the measures of the visual spectrum of α Tauri by Huggins and Vogel, whose identifications of lines with metallic lines he seems, with few exceptions, to consider worthless. Many readers will probably dissent from this view, as the agreement between the two observers is really good (as also conceded by the author), and this somewhat sweeping condemnation would apparently, if consistently applied, wipe out many conclusions drawn from spectroscopic observations.

In the section "Spectra of Type II*b*" the translator has put together a large amount of information not to be found in the original, by giving a list of fifty-five stars of this class (which are with few exceptions in or close to the Milky Way), and a list of bright lines in the visual spectra of thirty-one of them, recently observed by Campbell at the Lick Observatory. The existence of a large envelope of incandescent hydrogen about one of these stars (D.M. + 30°, 3639) seems to be proved by Campbell's latest observations, according to which the F line, observed with a narrow slit, is a long line extending to a very ap-

preciable distance on each side of the continuous spectrum, and with an open slit is a large circular disc about 6" in diameter. The same appearance is noticeable in the faint Hγ and very faint Hα lines, but not in other lines.

The section on Temporary Stars has also been very considerably extended by the translator, by the addition of a detailed account of the observations of Nova Aurigæ and of the various theories which have been proposed to account for the manifold phenomena exhibited by this object. The difficulties in the way of accepting any one of these hypotheses as fully satisfactory are pointed out, and it seems impossible to deny that there must have been more than two bodies in action. The complete transformation of the spectrum at the revival of the star, so strikingly similar to that discovered by Copeland in the case of Nova Cygni, is also an awkward fact to deal with, and one that cannot be avoided by merely denying that we have here "a star turned into a planetary nebula." The interpretation of the nebulous appearance of the star as caused simply by the chromatic aberration of the blue hydrogen rays, when the telescope is focussed for the most intensive rays of the chief nebular line 5002, seems untenable, as so experienced and sharp-sighted an observer as Prof. Barnard has recently declared himself to be absolutely sure, that the nebulous appearance is not a mere telescopic effect (*Astr. Nach.* 3238). And why should we think it impossible for the object to *look* like a nebula, when it has the unmistakable spectrum of one, and when we remember the above-mentioned observation by Campbell of D.M. 30°, 3639? The objects which caused the outburst in December 1891 probably left the scene of the catastrophe a few months after, leaving behind them masses of gas both visually and spectroscopically seen as a nebula. But, as pointed out by Prof. Frost, the most difficult facts to explain are the enormous relative velocities of the objects.

The study of the spectra of Type III*a* has, during the last few years, produced results which have very much lessened the supposed similarity between these spectra and those of sun-spots, and the development of bright lines in many spectra of long-period variables at their epochs of maximum obliges us to give up the ideas which formerly prevailed with regard to these variables. Here, as in the case of Nova Aurigæ and β Lyræ, we have evidently to do with very complex phenomena. The translator refers in a few words to the theory advanced by Mr. Lockyer, that the long-period variables may be systems of two swarms of meteorites revolving in elliptical orbits, and he dismisses it with the objection (which is not new) that the conditions in a system of this kind could not be permanent, as with successive collisions the smaller swarm would become spread out into a ring, thus causing the variability to cease. This objection is, however, not a serious one, as our own Leonids, though spread out into a ring, have for many centuries exhibited a very strongly marked maximum.

After describing the spectra of Type III*b*, the translator gives a summary of Pickering's statistical examination of the Draper Catalogue. He has omitted the short notice of the Meteoritic Hypothesis which Dr. Scheiner had inserted at the end of this chapter, and which hardly gave a fair idea of the hypothesis. The two remaining chapters are devoted to the spectra of the Aurora and Zodiacal Light, and the displacements of spectral lines as caused by the rotation of the sun, the motion of stars in the line of sight, or by spectroscopic binaries. A useful addition is given in the shape of a reprint of Campbell's formulæ and tables for the reduction of observations of displacement.

The fourth part of the book (pp. 361–426) contains a very valuable set of spectroscopic tables, viz. Rowland's new table of standard wave-lengths (*Astronomy and Astrophysics*, April 1893), Abney's wave-lengths of lines in the ultra-red spectrum, Kayser's and Runge's arc spectrum of iron, a catalogue of stars of classes III*a* and III*b*, and, lastly, an unpublished partial revision of the chromospheric lines by Young. Finally, on pp. 427–472, a bibliographical list is given of books and papers relating to astronomical spectroscopy. This list is unfortunately very incomplete, and glaringly so with regard to solar phenomena. We have, also, in several cases missed references to papers quoted in the body of the book, and in others only found references to short notices in NATURE, instead of to original memoirs.

On the whole, this English revised edition is a great improvement on the original, valuable as the latter undoubtedly was, and it forms both an excellent text-book for the student and a useful book of reference to workers in spectroscopy. J. L. E. DREYER.

AGRICULTURAL ZOOLOGY.

Agricultural Zoology. By Dr. J. Ritzema Bos, Lecturer in the Royal Agricultural College, Wageninen, Holland. Translated by J. R. Ainsworth Davis, B.A. With an introduction by Eleanor A. Ormerod. (London: Chapman and Hall, 1894.)

AGRICULTURISTS will be misled by the title of this book, if they expect to find any reference in it to farm animals which especially interest and concern them, such as horses, cattle, sheep, and pigs. There are no descriptions of these animals in this work upon agricultural zoology, although after having enumerated the thirteen orders of mammals, Dr. Ritzema Bos says he shall "deal only with those of agricultural importance," and forthwith leaves out all references to cattle, horses, sheep and pigs. But, on the other hand, such animals as wild boars, deer, otters, golden eagles, nightingales, herring-gulls, and grebes, having no connection with agriculture, are treated of at some length, and figures of them are given. Cuttle-fishes and star-fishes also seem out of place in a work entitled "Agricultural Zoology," which should rather have been styled "Zoology, or the Elements of Zoology."

Among the insects the migratory grasshopper (*Acridium migratorius*) and the Colorado beetle (*Doryphora decemlineata*) figure, though these are not British insects, nor are they likely ever to gain a foothold in this country. A work upon British Agricultural Zoology is much wanted that would give the cultivators accurate information upon all the animals that are in any way, directly or indirectly, serviceable to them, and all those that are harmful to them, directly or indirectly. Dr. Ritzema Bos just touches the fringe of this subject with regard to the larger animals, though, it must be admitted,

he goes into rather more detail concerning insects. Knowledge of the inner life of animals is most desirable, and should be spread through the whole of the country districts by the Technical Education Committees of County Councils, by means of competent lecturers, in the absence of any standard text-book on the subject. There is a capital book on Agricultural Zoology in France, compiled by Dr. Brocchi, entitled "Traité de Zoologie Agricole," in which detailed descriptions are given of all the animals that are useful and injurious to cultivators. Their habits (*mœurs*) are first detailed, then their use (*utilité*), or the harm (*dégâts*) occasioned by them, so that one may see at a glance those that may be counted upon as friends or foes. It might be supposed naturally that in a treatise upon Agricultural Zoology, Dr. Ritzema Bos would have dealt at some length with, for instance, such a useful bird as the kestrel (*Falco tinnunculus*), which must be held to be one of the best friends of the farmer, for it feeds upon mice, rats, and cockchafers. Swallows, martins, and swifts are dismissed with exceedingly short notices, and their indescribably good services to cultivators are unfairly depreciated in the following inconsistent passage :—

"Swallows fly quickly and catch insects while on the wing. The insects on which they prey are generally unimportant to agriculture and forestry ; but they may also do good by catching crane-flies (Tipula) and ribbon-footed corn-flies (Chlorops), which often fly about our fields in enormous swarms in order to lay their eggs."

It must be strenuously denied that the insects on which they prey are unimportant to agriculture, as they are known to be especially fond of aphides, and many hop-planters believe that the far greater frequency of the attacks of the *Phorodon* (*aphis*) *humuli* upon hop-plants in the last five years is due in a degree to the scarcity of swallows and martins. There is no doubt, also, that these birds clear off the Hessian fly, *Cecidomyia tritici*, and others of the *Cecidomyidæ*, and as they live entirely on insects, and especially on the smaller and most dangerous insects, they are of inestimable benefit, and should therefore be preserved with religious care. It is much to be lamented that swallows, martins, and swifts are so ruthlessly massacred in the sunny climes in which they pass the winter seasons. Plovers, too, whose value to farmers is inestimable, are not alluded to. This is an unfortunate omission, as it is desirable to clearly point out that these birds should be encouraged, and that the general raids upon their eggs, to satisfy the appetites of gourmets, should be stopped.

In his large, valuable work, "Tierische Schadlinge und Nützlinge für Ackerbau, Viehzucht, Wald- und Gartenbau," published at Berlin in 1891, Dr. Ritzema Bos, like Dr. Brocchi, gives full accounts of all animals in any way connected with the field, forest, and garden, and this might have been liberally epitomised and translated for the benefit of British agriculturists with far more advantage to them than the unsatisfactory *réchauffée* now before us. Insects are Dr. Ritzema Bos's strong point, as all are aware who know his labours in this direction, so that it is not surprising to find considerably more than a third of the contents of "Agricultural Zoology" devoted to them. But it is rather strange that some very important insects are not mentioned, and that others are dismissed with a short account of their habits. In some cases methods of prevention and remedies against insect attacks are suggested, but they are generally given in the briefest possible manner. Thus for the pea-weevil (*Sitones lineatus*) the remedy prescribed is "rational rotation," which will convey little or no meaning to the perplexed pea-grower.

For the ravages of the Diamond-back Moth (*Plutella cruciferarum*), no remedy whatever is mentioned, although the caterpillars of this insect occasionally do serious harm to many species of the Brassica, as in 1891, when many thousands of acres of turnips, rape, and cabbages were ruined by their action.

Another instance of a curious remedy may be given in the paragraph upon Cockchafers (*Melolontha vulgaris*) in which it is recommended that the grubs that are turned up during ploughing should be collected, and that the cockchafers should be caught. "This is very expensive, since it has to be done very energetically if most of them have left the pupa case. A part of the expense may, however, be recouped by using the cockchafers as manure." This "part of the expense," it is thought, would be absurdly infinitesimal.

Again, for the Red Spider (*Tetranychus telarius*), most destructive to many crops of the farm, garden, and glass-house, no modes of prevention or remedial measures are hinted at, although economic entomologists have pointed out that as moisture is most obnoxious to these mites, washing or spraying infested plants frequently is an efficacious remedy against them. One of the best parts of this volume is that devoted to the *Anguillulidæ*, or eelworms, which are most injurious to a number of crops, and in many cases are quite unsuspected enemies.

With regard to the insects omitted, it will be seen that none that are injurious to fruit crops have been included, though fruit-growing forms an important feature of British land culture. As in Holland and Germany, the Winter Moth (*Cheimatobia brumata*) is terribly destructive to the apple crops in this country, and the Codlin Moth (*Carpocapsa pomonella*) is almost equally injurious in some seasons to apple-trees in Great Britain, the Continent, and the United States and Canada. Both these are unnoticed, as well as several other moths, and many weevils and sawflies, that attack apple, pear, and plum trees, gooseberry and currant bushes, and raspberry-canes, against whose onslaughts fruit-growers would only be too thankful to have some practical advice from an expert of the reputation of Dr. Ritzema Bos.

In a few instances valuable remedies are recommended against insects, as, for example, the remedy adopted for the Silver Y Moth (*Plusia gamma*), by fastening together by laths several long troughs with steep inner walls, at distances equal to those between the adjacent furrows, and the caterpillars are swept by besoms fixed to the laths into the troughs, from which they are collected in sacks at the end of the furrows. With this cheap machine about twelve acres per day can be cleared. This is a practical remedy, and is derived from Taschenberg, the most practical and able of all economic entomologists, who has done more for cultivators in the way of describing insects, and prescribing methods of

prevention and remedial measures against them, than any other entomologist; and whose store of information many writers upon economic entomology have calmly used without acknowledgment. His "Praktische Insekten-Kunde" is a model of what a work upon baneful insects should be.

The 149 illustrations in "Agricultural Zoology" are good, especially those from Taschenberg, which are very clear, and some of these form very pretty pictures. It would be a great assistance to readers if an index had been supplied, for it is difficult to find references that are required.

Upon the whole we cannot congratulate Prof. Ritzema Bos upon his last production. If he had reproduced parts of his larger work, "Tierische Schadlinge und Nützlinge," without alteration, it would have been far better than boiling it down and entitling the result "Agricultural Zoology."

OUR BOOK SHELF.

Progress in Flying Machines. By O. Chanute, C.E. (London: Messrs. Sampson Low, Marston, and Co., 1894.)

THIS book is a reissue of a series of twenty-seven articles which appeared in *The Railroad and Engineering Journal* (now re-designated as *The American Engineer*) of New York City. It gives a very complete account of the many experiments that have been performed by various experimenters with details of the machines used, and clear reasons why so many of them have failed. After a short statement of general principles the author describes the machines in which wings and parachutes were used; then those in which screws were used to lift and to propel. The author believes that the true function of aerial screws is to propel and not to lift (page 72); but Lord Kelvin, in the discussion on aerial navigation at the British Association in Oxford, last August, stated his belief in screws working round a vertical axis for the latter purpose. The greater part of the book is devoted to a description and discussion of aeroplanes. The whole subject of aerial navigation resolves itself into ten problems or conditions:

(1) The resistance and supporting power of the air.
(2) The motor, its character and its activity.
(3) Selection of the instrument to obtain propulsion.
(4) The form and kind of the apparatus for sustaining the weight—whether flapping wings, screws, or aeroplanes.
(5) The amount of the sustaining surface required.
(6) The best materials to be employed for the framing and for the moving parts.
(7) The maintenance of the equilibrium, which is the most important, and perhaps the most difficult of solution, of all the problems.
(8) The guidance in any desired direction.
(9) The starting up into the air under all conditions.
(10) The alighting safely anywhere. Safety in starting up, in sailing, and in coming down is essential.

All these problems are fully and fairly discussed in this volume. There are eighty-two diagrams, and an excellent index, which add greatly to the value of the book.

Fertilisers and Feeding Stuffs; their Properties and Uses. By Bernard Dyer, D.Sc. (Lond.) (London: C. Lockwood and Co., 1894.)

THIS little book, which is a handbook for practical farmers, and is not addressed to the agricultural student, is issued opportunely. It contains the full text of the Fertilisers and Feeding Stuffs Act 1893, and the Regulations and Forms of the Board of Agriculture relating to the same, and also some useful notes on the Act, by Mr. A. J. David, Barrister-at-Law. Dr. Dyer's notes were first published in the form of newspaper articles, and have been reprinted by request; they will prove very useful to the class to whom they are addressed, containing as they do short descriptions of the origin, composition, and uses of farmyard manure, artificial manures, and of purchased feeding stuffs, all of a practical nature. The notes on the new "Fertilisers and Feeding Stuffs Act" will also be useful to those who wish to put this Act into use; but these, we anticipate, will be few.

Heat treated Experimentally. By Linnaeus Cumming, M.A. (London: Longmans, Green, and Co., 1894.)

THE companion volume to this—"Electricity treated Experimentally"—is known to most teachers of physics. The present work aims at giving (1) an elementary account, with easy experiments, of the general laws of heat; (2) a brief account of the classic researches of Regnault, Joule, and other eminent investigators; (3) a description of the theory of heat comprehensible to students whose mathematical range does not extend beyond elementary trigonometry. This laudable design is satisfactorily realised. Mr. Cumming writes clearly; in other words, he knows what to say and how to say it. The experiments described are all workable and well arranged, hence the book is one which may be used in science classes with confidence and pleasure.

Ways and Works in India. By G. W. Macgeorge, M.I.C.E. (Westminster: Constable and Co., 1894.)

AN account of the public works in India from the earliest times up to the present day should be useful, if only as an outline for a precise and detailed history of Indian Public Works. The materials for the compilation before us have been collected by the author from various official publications, and the facts are arranged in a satisfactory manner. The subjects treated are the trigonometrical survey of India; roads; irrigation works; railways; water-supply of towns; internal telegraphic system; and sea and harbour works. The data referring to these matters will be valuable to all interested in the progress of India. The work does not appeal to a large public in England; nevertheless, it presents, in a readable form, much useful information on the engineering works which will stand for many years as monuments to British rule in India.

Manual Pratique de L'Aéronaute. By W. de Fonvielle. (Paris: Bernard Tignol.)

IN this book of 246 pages, M. de Fonvielle, a well-known writer on aeronautical matters, contrives to compress a mass of information of use to the aeronaut. We recommend the book to practical aeronauts, meteorologists, and the numerous amateurs who are interested in ballooning and its possibilities. Seventy figures illustrate the text. It has been said that the development of the art of flying has been retarded by the balloon; but even if this is conceded, M. de Fonvielle's book shows that science has gained a little from ballooning.

Fruit Culture for Profit. By C. B. Whitehead, B.A. Pp. 68. (London: Society for Promoting Christian Knowledge, 1894.)

IN view of the recent correspondence in the *Times*, on fruit culture, this book appears very opportunely. Fruit-growing is now recognised as a valuable branch of agriculture, and English producers are becoming alive to its importance. The Royal Agricultural Society and the Board of Agriculture have encouraged fruit-growing by publishing articles and pamphlets upon the subject. These publications, and Mr. Whitehead's little volume, should be obtained by all who are interested in the profitable production of fruit.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Wilde's Theory of the Secular Variation of Terrestrial Magnetism.

SOME prominence is given in NATURE of August 9 to a letter of L. A. Bauer, a magnetic computer of the United States Coast and Geodetic Survey, on the above subject. Absence from home and other circumstances have prevented me from replying to this letter before now. It is not my intention to engage in controversy with a critic who roundly condemns my theory and experiments without reason, and at the same time naïvely announces that, by means of formulæ established by himself, he has succeeded in representing the observations many times better than the magnetarium results.

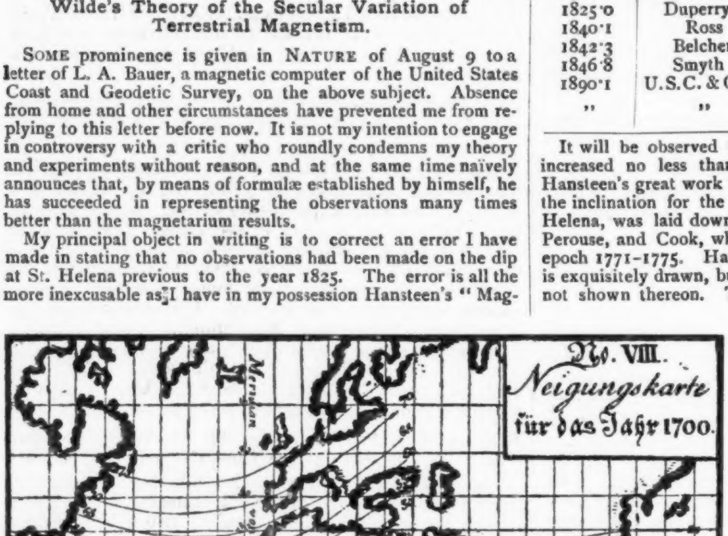
My principal object in writing is to correct an error I have made in stating that no observations had been made on the dip at St. Helena previous to the year 1825. The error is all the more inexcusable as I have in my possession Hansteen's "Magnetismus der Erde," with its valuable atlas-folio of charts of the magnetic variation, from which L. A. Bauer has derived his information of the dip at St. Helena for the epoch 1700–1780. Had I said that no *reliable* observations had been made before 1825, the statement would hardly have called for any notice. It is well recognised by magneticians that observations of the dip, up to the early part of the present century, were much more difficult to make than those of the declination, on account of instrumental imperfections and the unrecognised influence of vertical masses of ship's iron and local geological formations. Sabine, in his "St. Helena Observations," vol. 2, p. lxv., shows a difference of between 2° and 3° at Longwood and Sister's Walk, from the latter cause, and this illustrious magnetician did not venture to give observations of the dip further back than the epoch 1825.

I regret to observe that L. A. Bauer, in his intolerance of the magnetarium results, has inserted in his table guesses of his own for observations, which are very wide of the truth.

In order that my remarks on the dip at St. Helena may be better understood, I will, by your permission, reproduce the table of L. A. Bauer, although that of Sabine and the Admiralty chart are more in agreement with my results.

Date.	Observer.	Observed inclination.	Wilde inclination.	Observation Theory.
1700	Hansteen chart	11°·5 S.	3°·9 N.	−15°·4
1754·3	La Caille	9·00	0·5 S.	− 8·5
1771·4	Ekeberg	13·00	3·5	− 9·5
1775·4	Cook	11·42	4·0	− 7·4
1780	Hansteen chart	10·5	5·1	− 5·4
1825·0	Duperry	14·93	14·7	− 0·2
1840·1	Ross	18·27	18·5	+ 0·2
1842·3	Belcher	17·00	19·0	+ 2·0
1846·8	Smyth	19·39	20·5	+ 1·1
1890·1	U.S.C. & G.S.	29·65	33·8	+ 4·1
,,	,,	31·18	33·8	+ 2·6

It will be observed that for the epoch 1825–1890, the dip increased no less than 16°·25, or fifteen minutes annually. Hansteen's great work was published in 1819, and his curve of the inclination for the epoch 1780, showing 10°·5 S., at St. Helena, was laid down from the observations of Ekeberg, La Perouse, and Cook, which indicate a diminishing dip for the epoch 1771–1775. Hansteen's chart of the inclination for 1700 is exquisitely drawn, but on a scale so small that St. Helena is not shown thereon. The position of the island is, however, easily found from the latitude 15° 55′ S., and long. 5° 43′ W., or 12° E. of the meridian of Ferro.



As Hansteen's historical work on the magnetic variation is very rare, I have had his chart of the inclination for the epoch 1700 reproduced by a photographic process, with the position of St. Helena dotted thereon, for the benefit of your readers.

It will be seen from the chart that the magnetic equator, or line of no dip, is about 1° north of St. Helena, so that the amount of south dip would not be more than 2° for the epoch 1700. Hansteen would appear to have laid down his curve of the dip for 1700 from the previous observations of Ekeberg and La Caille, which indicate a decrease, reckoning backwards, from 1771 to 1754; but he nowhere states in the text of his work, that his curve was drawn from an observation made at St. Helena in 1700.

The amount of dip, 11°·5, shown by L. A. Bauer for 1770, is the same as that observed by Cook in 1775, and is an obvious blunder in his reading off the position of St. Helena 1° below the isoclinal of 10° south, instead of from the magnetic equator.

I shall leave others to judge how far any statements of L. A. Bauer on the subject of terrestrial magnetism in general, and on the magnetarium in particular, are entitled to credit when he places his erroneous computation under the heading of observed inclinations standing against the distinguished names set forth in his table.

It may be of interest to magneticians to know that the secular changes shown in my tables of the declination and inclination at London, Cape of Good Hope, St. Helena, and Ascension Island are obtained conjointly on the magnetarium without change of resistance in the secondary circuit; together with the great eastern and western lines of no declination, the Asiatic oval of small westerly declination, the oval of small easterly declination in the Pacific, the magnetic equator, and many other agreements with the observations, all for the epoch 1880.

I regret that I have not been able to accomplish more; but in reply to the remark of L. A. Bauer that although I possess the records of secular variation stations in the United States, I have made no published attempt to reproduce them, I may say that two years ago I presented a magnetarium to the United States Coast and Geodetic Survey, at considerable cost and trouble to myself, with full instructions for working it, and have no doubt that the department will make good use of the instrument.

Alderley Edge, September 28. HENRY WILDE.

The Newtonian Constant of Gravitation.

I SHOULD be obliged if you would allow me to make a correction in my lecture at the Royal Institution, published in NATURE, Aug. 2, 9, and 23, on page 331. I have stated that in pieces of apparatus geometrically similar but of different dimensions, the disturbances due to uncertain convection currents are likely to be in the proportion of the seventh power of the linear dimensions. Having discussed this at some length lately with Prof. Poynting, I find that I was in error, and that in reality the disturbances would be proportional to the fifth power of the linear dimensions if the circulation of the air were so extremely slow as to be steady. If, however, its velocity were sufficient to give rise to unsteadiness, the rate at which momentum would be given to the suspended portion of the apparatus would depend on the square of the velocity, at least in part, and as the part depending on the square increased in importance the disturbance would gradually rise to the eighth power. So long, therefore, as the apparatus is small enough to prevent terms involving the square of the velocity from being appreciable, the ratio of the disturbance to the couple to be measured or the stability is the same whatever the size; but as soon as the apparatus exceeds this, then the disadvantage of size very rapidly becomes evident.

Of course the objection due to the great increase of time which must elapse between the handling of apparatus and its being fit for observations to be made, which accompanies increase of size, remains.

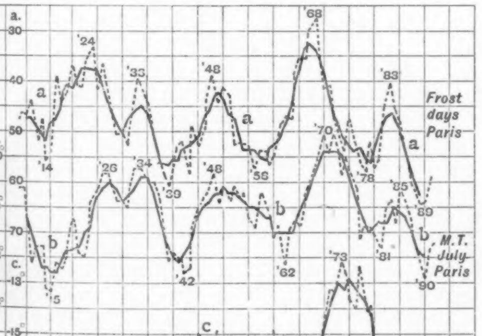
As the consideration of the relation between disturbance and couple to be measured, and its variation with linear dimensions, is a matter of great importance in the design of most instruments in which the movements of a suspended system supply the means of measurement, there is an additional reason for correcting in these columns the error that I made.

C. V. BOYS.

On Some Temperature-Variations in France and Greenland.

THE relations indicated in the diagram sent herewith are, I think, instructive; and they might perhaps be found to contain some useful clues to coming weather.

This diagram has two kinds of curves, dotted line, and continuous. Both are *smoothed* curves. In the former, the actual



values have been smoothed with averages of five; and in the latter, those averages have, in their turn, been treated in the same way. High points in all the curves denote heat; low points cold.

The first pair of curves (a) show, by averages, the variation in the number of frost days in Paris in October to April of each cold season since 1806. (I designate each cold season by the year in which it *ends;* 1806 meaning 1805 6, &c.). These are *inverted* curves, the numbers increasing downwards. They present a succession of (say) five obvious waves, which, with regard to the crest intervals, are neither wholly regular nor wholly irregular, the intervals of the smoother curve being, in series, 12, 15, 18, and 17 years.

The second pair of curves (b) show the variation in mean temperature of July at Paris during the same period; and we may perceive in these a general correspondence to the first curves, with, however, a distinct tendency to lag somewhat.

There is a good deal of general similarity, of course, between the weather of Paris and our own, and between the longer waves of variation of July and those of the whole summer. Hence we find, *e.g.*, that a once-smoothed curve of mean temperature of summer at Greenwich presents obvious minima in the years 1814, 1839, 1862, and 1881. Compare this with the Paris July curve.

It is known that in our climate a severe winter tends to be followed by a cool summer; but the facts here presented are, it will be perceived, of a somewhat different order, and wider scope.

The third pair of curves (c) relate to Jakobshavn, on the west coast of Greenland, and show the smoothed variations in mean temperature of winter (December–February) for a series of years. These curves are short compared with the others, and are interrupted at one part; but so far as they go, they seem to present a similar variation, with further lag; so that, as compared with the Paris frost curve, we find the phases have come to be nearly opposite. Our European winters, indeed, seem to be generally opposite to those of Greenland. This is pointed out, as regards Vienna, by Dr. Hann in the paper from which those Jakobshavn figures are obtained. (*Met. Zeits.* 1890, p. 113.)

By way of comparing these curves, it may be useful to note the lowest points of the three once-smoothed curves; and the intervals between those of the same curve and of different curves. (The intervals, in years, are given in brackets.)

Paris, frost,	1814 (25),	1839 (17),	1856 (22),	1878 (11),	1889
	(1)	(3)	(6)	(3)	
Paris, July,	1815 (27),	1842 (20),	1862 (19)	1881 (9),	1890
		(2)	(3)	(3)	
Jakobshavn, winter,		1844 (21),	1865 (19),	1884.	

The fact of this lagging correspondence would appear to suggest that the general variations of our winter seasons are, in some measure, a key to those of approaching summers, and also, if the Jakobshavn correspondence were confirmed by a longer series of data, to those of approaching winters in Greenland.

An explanation of these curious facts may perhaps be supplied by those who have a comprehensive knowledge of polar meteorology and its relations.

A. B. M.

New Element in the Sulphur Group.

DR. B. BRAUNER, of Prag, in 1888 made a careful investigation of the atomic weight of tellurium, an account of which will be found in *C. S. J.* 320, p. 382. In accordance with Messrs. Newland's and Mendeléef's Periodic Law, tellurium should have, if pure, an atomic weight of 125, or even lower.

Prof. D. Mendeléef takes Sb = 122, Te = 125, I = 127. Taking the latest numbers for antimony and iodine (Sb = 120, I = 126·8), Dr. Brauner proceeds to investigate the atomic weight of Te, for which he finds by a great number of experiments the number 127·65. As is only to be expected from such a staunch advocate of the Periodic Law, he at once came to the conclusion that neither himself nor former experimenters (Berzelius, in 1812, 1818 and 1832; von Hauer, in 1857, &c.) had been dealing with the pure element. As he puts it, tellurium is not an element.

Tellurium prepared from the dibromide gave the high atomic weight of 130. Prepared from the tetrabromide, which latter was distilled in vacuo, the resulting element being distilled in a current of hydrogen, Te = 127·65. Under these circumstances, he says, no doubt one constituent of "tellurium" partly escapes, thus reducing the atomic weight. He terms tellurium the gadolinium of the sulphur group.

In the following year, 1889, Prof. Mendeléef predicted (Faraday Lecture, *C. S. J.* 323, p. 649) an element with atomic weight 212, which he calls Dvi-(=Bi-) tellurium, for which he suggests the symbol Dt, and predicts the following

characters: it will be capable of forming an oxide RO_3; its hydride, if it exists, will be even more unstable than tellurium hydride; its compounds will be easily reduced; it will form definite alloys with metals; and have the specific gravity of about 9·3. Since then Prof. W. Preyer, in his "Genetisches System der chemischen Elemente," Berlin, 1893, p. 100, among unknown elements, gives one in the sulphur group, thus predicted by Mendeléef. He goes into further details, representing the atomic weight as 213; specific gravity, 8·6; atomic volume, 24·7; specific heat, 0·03; electro-negative, divalent, diamagnetic.

A. Grünwald (Bl. 1891, 5, p. 21) appears to have seen the spectrum of this element, whilst observing spectra of tellurium, copper and antimony.

Norwegium is considered by some chemists to be this missing element; Dr. Preyer is not of that opinion, regarding the claims of norwegium to be considered an element to be insufficiently supported.

In consideration of Dr. Brauner's work on the atomic weight of tellurium, and the priority of his suggestion of the existence of an accompanying element of higher atomic weight, coupled with his excellent work generally in furthering the claims of the Periodic Law (notably in the cases of beryllium and of the cerium, lanthanum and didymium series), I would suggest that this new element, when isolated from its close union with tellurium, be called Bohemium, in his honour.

C. T. BLANSHARD.

Bright Meteors.

A PRETTY bright meteor crossed the eastern sky here on Saturday evening last, at about 7.54 p.m. I saw only the flash of light which it cast on the ground and in the sky towards the east, like a momentary weak red flash of lightning. "A shooting-star," said a bystander close to me, who saw it fairly well, and who gave me, roughly, this description, by the stars, of its apparent course: From about R.A. 340°, Decl. + 25°, to about 336°, + 12°. It described this course of 12° in about a second, and was red in colour, and broke up at last with a red flash, leaving no train of light or of sparks along the track which it had traversed, so long as for a second or two in which I had time to look towards the direction where he pointed. Tree-tops intercepted his view beyond the point of this disruption, but the light's sudden extinction there made a much further extension of the track unlikely.

About an hour afterwards, at about 8.49 p.m., I chanced to see another rather fine shooting-star, of about the brightness and colour of the planet Mars at present, descending some 16° or 18° across the northern sky in one and a-half or two seconds, from R.A. 47°, Decl. + 70°, to 100° + 69°, beginning and disappearing rather suddenly, and of nearly uniformly bright appearance all along its course. It projected no sparks, and, like the earlier meteor, left no train of light or enduring sparks along its track to mark its course.

Prolonged backwards the apparent paths of these two meteors diverge from near α Cassiopeiæ, and it may perhaps be that a shower of bright, ruddy meteors from the direction of Cassiopeia was in progress on that date, of which the two meteors here described may have been bright enough members to have been generally noted. The above observations, although those of the brighter meteor are only of rather slender accuracy, will perhaps be useful, in that case, to serve for comparison with other records which, at least of the larger meteor of the two, may not impossibly have been noted and preserved elsewhere.

A. S. HERSCHEL.

Observatory House, Slough, October 1.

Tan-Spots over Dogs' Eyes.

CAN any of your readers explain the meaning of the tan-spots seen so commonly over the eyes in black-and-tan dogs of most breeds?

When in Melbourne last year, I went carefully over all the dogs in a show, with one of the stewards, and we found the spots in all the black-and-tan terriers, foxhounds, deerhounds, collies, lurchers, &c.; but I could get no information regarding them from the experts.

In some of the highly-bred toy dogs, as the small black-and-tan terriers, I found on inquiry that these spots, formerly so very conspicuous, were being bred out, and had *nearly* disappeared. Their persistence through so many strongly-marked varieties, except those of late date, is singular, for there is fairly good proof that when first domesticated the dog was red or bright brown, like the pariah, dingo, &c.

As far as I can see, we do not find the spots white on a black or dark ground; nor yet black or dark on a white or light ground. My explanation is that they have arisen as a permanent marking after the dogs "sported" to black under domestication, and have been preserved and developed through natural selection. Possibly they are protective, and simulate *eyes*.

One morning, just at dawn, I had occasion to go out into the garden, and while stooping to examine some flowers, near a fence partly covered with creepers, I suddenly saw an animal's head looking through, and what seemed to be two black, and seemingly large, eyes glared at me. Suspecting that a black leopard was about to spring over, I started back, clapped my hands, and shouted. To my relief, however, I saw a tail wag, and found that the spectator was a coolie's dog I knew very well, and which recognised me. The use of the tan-spots—in this case at least—then occurred to me.

May it not be that the spots thus serve a protective purpose, and have often saved the lives of dogs (black dogs) from their enemies, the smaller felines, such as the clouded leopard, &c.? Perhaps the matter is not new; but if it is, it seems worth looking into.

I have several dogs about here now with black bodies and heads; the tan-spots, rather pale, are of the size of a shilling. I have shot one, keeping the skin of the head as a curiosity.

Sibsagar, Asam, September 7. S. E. PEAL.

Flight of the Albatross.

AT the request of several friends, I enclose, for your inspection, a snap-shot of a northern albatross, which I took *en route* from Victoria, British Columbia, to San Francisco.

The photograph gives the bird in a position in which the human eye is incapable of seeing it. Strangely enough, the flight of the bird which I photographed had been during the whole course of the morning the subject of much discussion: none of us could imagine how the force which enabled it to fly at such

great speed was generated. I remembered having seen some discussion in the papers on the subject, and stated that the matter had been settled to the satisfaction of scientific people, and did my best to explain the theory.

I chose the moment for my photograph when the bird was about fifteen feet from the camera, and sailing alongside of the steamer. The stretch of the wings was estimated by the

captain of the ship at between eleven and twelve feet, and the indicator on the camera showed these wings apparently at full stretch at the instant that I pressed the button. The result is certainly somewhat astonishing, and I shall be glad to know whether it is worth comment in your paper; to me it certainly seems to entirely upset the accepted theories as to the flight of this bird.

A. KINGSMILL.

Stanmore, October 10.

ON THE DOCTRINE OF DISCONTINUITY OF FLUID MOTION, IN CONNECTION WITH THE RESISTANCE AGAINST A SOLID MOVING THROUGH A FLUID.[1]

III.

§ 11. THE accompanying diagram (Fig. 1) illustrates the application of the doctrine in question, to a disk kept moving through water or air with a constant velocity, V, perpendicular to its own plane. The assumption to which I object as being inconsistent with hydrodynamics, and very far from any

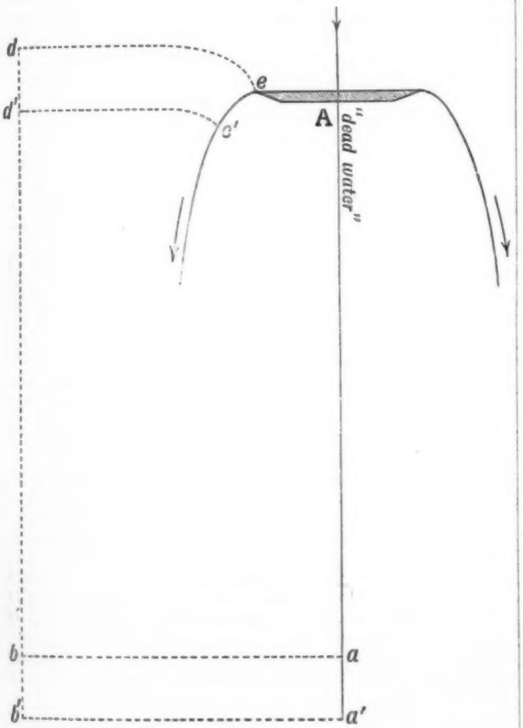


FIG. 1.

approximation to the truth for an inviscid incompressible fluid in any circumstances, and utterly at variance with observation of disks or blades (as oar blades) caused to move through water; is, that starting from the edge as represented by the two continuous curves in the diagram, and extending indefinitely rearwards, there is a "surface of discontinuity" on the outside of which the water flows, relatively to the disk, with velocity V, and on the inside there is a rear-less mass of "dead water"[2] following close after the disk.

§ 12. The supposed constancy of the velocity on the outside of the supposed surface of discontinuity entails for the inside a constant pressure, and therefore quiescence relatively to the disk, and rearlessness of the "dead water." How such a state of motion could be produced? and what it is in respect to rear? are questions which I may suggest to the teachers of the doctrine, but happily, not going in for an examination in hydrokinetics, I need not try to answer.

§ 13. But now, supposing the motion of the disk to have been started some finite time, t, ago, and considering the consequent necessity (§ 9) for finiteness of its wake, let ab, bd be lines sufficiently far behind the rear, and beyond one side, of the disturbed water, to pass only through water not sensibly disturbed. We thus have a real finite case of motion to deal with, instead of the inexplicably infinite one of § 11. Let us try if it is possible that for some finite distance from the edge, and from the disk on each side, the motion could be even approximately, if not rigorously, that described in § 11, and indicated by the diagram.

§ 14. Let v be the velocity at any point in the axis, Aa, at distance y from the disk, rearwards. Draw ed perpendicular to the stream lines of the fluid, relatively to the disk supposed at rest.

The "flow"[1] in the line ed is 0;
" " " db " $V \times db$;
" " " ba " 0;
" " " aA " $-\int_0^{Aa} v\,dy$;
" " " Ae " 0, by hypothesis.

Hence for the "circulation"[2] in the closed polygon $edba$Ae, we have

$$V \times db - \int_0^{Aa} v\,dy.$$

Similarly, for the circulation in the same circuit[3] at a time later by any interval, τ, when the line ba has moved to the position $b'a'$, and ed to $e'd'$, we have

$$V \times db - \int_0^{Aa} v'\,dy.$$

where v' denotes, for the later time, $t+\tau$, the velocity in Aa, at distance y from A. Hence the circulation in edaAe gains in time τ an amount equal to

$$-\int_0^{Aa} (v'-v)\,dy;$$

which is the same as

$$-\int_0^{\infty} (v'-v)\,dy,$$

This, by the general theorem of "circulation,"[4] must be equal to the gain of circulation in time τ, of all the vortex-sheet in its growth from the edge according to the statement of § 11. Hence, with the notation of § 10,

$$(\Sigma\kappa)' - \Sigma\kappa = -\int_0^{\infty} (v'-v)\,dy.$$

§ 15. Remarking now that the fluid has only continuous irrotational motion through a finite space all round each of the lines ed, db, ba, aA; and all round Ae except the space occupied by the disk and the fluid beyond its front side, we have, for the velocity-potential of this motion, relatively to the disk,

$$Vy + \phi(x, y, z, t)$$

where ϕ denotes the velocity-potential of the motion

[1] Continued from p. 549.
[2] This is a technical expression of practical hydraulics, adopted by the English teachers of the doctrine of finite slip between two parts of a homogeneous fluid, to designate water at rest relatively to the disk.

[1] "Vortex Motion" (Thomson), *Trans. R.S.E.*, 1869.
[2] *Ibid.*
[3] Remark that the circulation in $abb'a'$ is zero, and therefore the circulation in $edb'a'$Ae is equal to that in $edba$Ae.
[4] "Vortex Motion," *Trans. R.S.E.*, 1869.

relative to the infinitely distant fluid all round: and we have

$$v = \mathrm{V} + \frac{d}{dy}\phi(o, y, o, t).$$

With this the equation of § 14 becomes

$$(\Sigma\kappa)' - \Sigma\kappa = \}\phi(o, o, o, t+\tau)\} - \{\phi(o, o, o, t)\}.$$

Hence, by taking τ infinitely small,

$$\frac{d}{dt}\Sigma\kappa = \frac{d}{dt}\phi(o, o, o, t).$$

§ 16. Now in the time from t to $t + \tau$, there has been, according to the supposition stated in § 11, a growth of vortex sheet from e, at the rate $\frac{1}{2}$V, being the mean between the velocities of the fluid on its two sides,[1] and the circulation, per unit length, l, of the sheet thus growing is lV. Hence the vortex-circulation of the growing sheet augments, in time τ, by $\frac{1}{2}\mathrm{V}\tau \times \mathrm{V}$: and therefore, by § 15,

$$\frac{d}{dt}\phi(o, o, o, t) = \tfrac{1}{2}\mathrm{V}^2.$$

§ 17. Now, if Π denotes the pressure of the fluid at great distances, where its velocity, relative to the disk is V, and p the pressure at any point of the rear side of the disk, being the same as the pressure at A, we have, by elementary hydrokinetics,

$$p = \Pi + \tfrac{1}{2}\mathrm{V}^2 - \frac{d}{dt}\phi(o, o, o, t)$$

because the velocity of the fluid at every point of the rear side of the disk is zero according to the assumption of "dead water." Hence, by § 16,

$$p = \Pi,$$

which, being the same as the pressure on the rear side given by the unmitigated assumption of an endless ever broadening wake of "dead water," proves that our substitution (§ 13) of a finite configuration of motion conceivably possible as the consequence of setting the disk in motion at some finite time, t, ago, instead of the inconceivable configuration described in § 11, does not alter the pressure on the rear side of the disk.

§ 18. Hence were the motion of the fluid for some finite distance from the disk, on both its sides, the same, or very approximately the same, as that described in § 11, the force that must be applied to keep it moving uniformly would be the same, or very approximately the same, as that calculated by Lord Rayleigh from the motion of the fluid supposed to be wholly as described in § 11.

§ 19. But what reason have we for supposing the velocity of the fluid at the edge, on the front side of the disk, to be exactly or even approximately equal to the undisturbed velocity, V, of the fluid at great distances from the disk? None that I can see. It seems to me indeed probable that it is in reality much greater than V, when we consider that, with inviscid incompressible fluid in an unyielding outer boundary, the velocity, in the case considered in § 14, is equal to V at even so far from the edge as ·85 of an inch, and increases from V to 63·7 × V between that distance from the edge, and the edge with its 1/2000 of an inch radius of curvature.

§ 20. And what of the "dead water" in contact with the whole rear side of the disk which the doctrine of discontinuity assumes? Look at the reality and you will see the water in the rear exceedingly lively everywhere except at the very centre of the disk. You will see it eddying round from the edge and returning outwards very close along the rear surface, often I believe with much greater velocity than V, but with no steadiness; on the contrary, with a turbulent unsteadiness utterly unlike the steady regular motion generally assumed in the doctrine of discontinuity.

[1] Helmholtz; Wissenschaftliche Abhandlungen; vol. i., foot of p. 151.

§ 21. We may I think safely conclude that on the front side the opposing pressure is less than that calculated by Rayleigh. That this diminution of resistance is partially compensated or is over-compensated by diminution of pressure on the rear, is more than we are able to say from theory alone, in a problem of motion so complex and so far beyond our powers of calculation: but we are entitled to say so, I believe, by experiment. Rayleigh's investigation of the resistance experienced by an infinitely thin rigid plane blade bounded by two parallel straight edges, when caused to move through an inviscid incompressible fluid, with constant velocity, V, in a direction perpendicular to the edges and inclined at an angle i to the plane, gives a force cutting the plane perpendicularly at a distance from its middle equal to

$$\frac{3\cos i}{4(4 + \pi\sin i)}$$

of its breadth, and gives for the amount of this force in gravitation measure,

$$\frac{2\pi\sin i}{4 + \pi\sin i}\,\mathrm{PA},$$

where A denotes the area of one side of the blade, and P the weight of a column of the fluid of unit cross-sectional area, and of height equal to the height from which a body must fall to acquire a velocity equal to V.

§ 22. The assumption (§ 11) on which this investigation is founded admits no velocity of fluid motion relatively to the disk greater anywhere than V. It gives velocity reaching this value only at the edges of the blade; and at the supposed surface of discontinuity; and in the fluid at infinite distances all round except in the infinitely broad wake of "dead water" where the velocity is zero. It makes the pressure equal to Π all through the "dead water," and makes it increase through the moving fluid, from Π at an infinite distance and at the "surface of discontinuity," to a maximum value $\Pi + \mathrm{P}$ attained at the water-shed line of the disk. If the fluid is air, and if V be even so great as 120 feet per second (1/10 of the velocity of sound)[1] P would be only 7/1000 of Π. The corresponding augmentation of density could cause no very serious change of the motion from that assumed: and therefore in Rayleigh's investigation air may be regarded as an incompressible fluid if the velocity of the disk is anything less than 120 feet per second.

We may therefore test his formula for the resistance, by comparison with results of careful experiments made by Dines[2] on the resistance of air to disks and blades moved through it at velocities of from 40 to 70 statute miles per hour (59 to 103 feet per second).

§ 23. Dines finds for normal incidence the resistance against a foot-square plate, moving through air at m British statute miles per hour to be equal to ·0029 m^2 of a pound weight.

This, if we take the specific gravity of the air as 1/800, gives according to our notation of §21,

$$1\ 116 \times \mathrm{PA}$$

as the resistance to a square plate of area A. At the foot of p. 255 (*Proc. R.S.*, June 1890) Dines says that he finds the resistance to a long narrow blade to be more than 20 per cent. greater than to a square plate. For a blade we may there take

$$1{\cdot}34 \times \mathrm{PA}$$

as the resistance according to Dines' experiments. This is 1·52 times the resistance calculated from Rayleigh's formula (§ 21 above), which is

$$\cdot 88 \times \mathrm{PA},$$

for normal incidence.

§ 24. For incidences more and more oblique, the dis-

[1] Or $\frac{1}{10} \times \sqrt{1{\cdot}4 \times g\mathrm{H}}$, where H is "the height of the homogeneous atmosphere."

[2] *Proc. R.S.E.*, June 1890.

crepancy is greater and greater. Thus, from curves given by Dines (p. 256) showing his own and Rayleigh's results, I find the normal resistance to a blade moved through air in a direction inclined 30° to its plane, to be 1·82 times that given by Rayleigh's formula. And by drawing a tangent to Dines' curve at the point in which it cuts the line of zero pressure, I find that, for very small values of *i*, it gives

$$3{\cdot}25 \times \sin i \times PA.$$

This is rather more than double the value of the force given by Rayleigh's formula for very small values of *i*, which is

$$\tfrac{1}{2}\,\pi \sin i . PA.$$

It is about three and a half per cent. greater than that given by my conjectural formula (NATURE, August 20, p. 426, and September 27, p. 525; and *Phil. Mag.*, October 1894) for very small values of *i*, which is

$$\pi \sin i \cos i.\ PA.$$

My formula is, however, merely conjectural; and I was inclined to think that it may considerably under-estimate the force. That it does so to some degree is perhaps made probable by its somewhat close agreement with Dines; because the blade in his experiments was 3*i* broad and ⅜ of an inch thick in the middle with edges "feathered off." An infinitely thin blade would probably have shown greater resistances, at all angles, and especially at those of small inclination to the wind.

(*To be continued.*)

OBSERVATIONS ON YOUNG PHEASANTS.

THE pheasants which formed the subjects of the following observations were hatched out in an incubator from eggs kindly given me by Sir Cecil Miles. The eggs were taken from the hen and transferred to the incubator a few days before the young birds were due to emerge.

The accuracy of pecking and seizing was found to be about the same as that of newly-hatched chicks. For example: two pheasants were hatched out at about 3 p.m.; that evening, at about 6.30, finely chopped egg was placed before them, but they showed no signs of pecking at it; nor did they peck at grain or sand next morning at 11 a.m. At 4 p.m. they began to peck, but seized very little. One struck repeatedly at a crumb of egg on the other's back, but failed to seize it, though the other bird was quite still. On the following morning they pecked at sand and grain (chiefly canary seed) with fair aim. One seized, at the first stroke, a grain of boiled rice at the end of a long steel pin. Another pheasant was hatched out in the night. At about 12 noon, I offered him some egg-bread on the end of a tooth-pick. He struck at it and missed, struck a second time and seized, swallowing some. He could not be induced to strike again. Later he picked up some ants' "eggs," striking with fair accuracy, but did not swallow any. At 4 p.m. he pecked some egg-bread off the end of the tooth-pick, and swallowed. He also pecked at an ant's "egg," but failed to swallow it; then at a second, and swallowed it. Further details would be merely wearisome. One may say that the co-ordination for pecking and swallowing is inherited in a condition such as to ensure fair but not complete accuracy; and that some individual experience is necessary to bring it to perfection.

The young pheasants took no notice whatever of water placed before them in a shallow vessel. When I gave them water on the tip of my finger, they seemed to enjoy it, and one in particular drank eagerly from the end of a tooth-pick, so that an association was established between the sight of the tooth-pick and the satisfaction of drinking. But when I lifted this bird and others, and placed them in the shallow vessel, they made no attempt to drink from it. They learnt to drink from the vessel through pecking at grains of food lying on the bottom. They drank, however, less freely than chicks.

The little birds showed no sign of fear of me. They liked to nestle in my warm hand. My fox-terrier was keen to get at them, much keener than with chicks, probably through scent-suggestion. I placed two of the young pheasants, about a day old, on the floor, and let him smell them (under strict orders not to touch them). He was trembling in every limb from excitement. But they showed no signs of fear, though his nose was within an inch of them. When the pheasants were a week old, I procured a large blind-worm and placed it in front of the incubator drawer in which the birds slept at night. On opening the drawer they jumped out as usual, and ran over the blind-worm without taking any notice of it. Presently first one, then another, pecked vigorously at the forked tongue as it played in and out of the blind-worm's mouth. Subsequently they pecked at its eye and the end of its tail. This observation naturally leads one to surmise that the constant tongue-play in snakes may act as a lure for young and inexperienced birds; and that some cases of so-called fascination may be simply the fluttering of birds round this tempting object. I distinctly remember when a boy seeing a grass-snake with head slightly elevated and quite motionless, and round it three or four young birds fluttering nearer and nearer. It looked like fascination; it may have been that each hoped to be the first to catch that tempting but elusive worm! Presently they would no doubt be invited to step inside.

Another incidental observation is worth recording here. I gave the young birds some wood-lice. These were frequently caught when they were moving, and eaten. But if one had time to roll up, and was thus seized, it was shot out to a distance by the pressure of the bill, just as a fresh cherry-stone is shot from between the finger and thumb of a school-boy. The protective value of the round and slippery form was thus a matter of observation.

I have not observed in the young pheasants the crouching down, which is seen in young chicks when an unusual sound startles them. They appear under such circumstances to stand motionless. For example, when two of them were walking about, picking up all the indigestible odds and ends they could find on my carpet, a high chord was sharply struck on the violin. Both stopped dead. The gentle piping noise they were making ceased. One of them was just lifting his leg, and remained in this position quite still, with neck stretched out, exactly as if he had been suddenly fixed in the attitude in which he chanced to be when the sharp sound fell on his ears. Thus he remained for half a minute. Then he took a few steps and again stopped, remaining quite still for about the same period. (Age 13 days.)

The method of tackling a worm appears to be a matter of inherited co-ordination. So soon as the worm is seized, it is shaken and battered about. There seems to be, also, an inherited tendency to run away with it to some distance before eating it. At all events, of two little pheasants, one of which was weakly, the stronger always bolted off with his worm, though his weakly brother or sister seldom or never chased him. He sometimes tried to bolt with one of his companion's toes by mistake, when one or both of the birds would topple over.

Two notes or sounds, one loud and distressful, the other soft and contentful, appear from the first to be clearly differentiated. A third sound, more gentle than the soft note and double, was occasionally heard when one caressed the birds in one's warm hand. It closely resembles a similar note uttered under similar circumstances by the chick. The note expressive of danger, alarm, or anger, was occasionally heard after about the

sixth day. For example, as the little pheasant was bolting with his worm, I seized it with a pair of forceps. This alarm or anger note was at once uttered, and the little fellow bridled up and seemed ready to show fight.

The birds when fresh run about with little short spurts or dashes, as do also chicks. They have a dislike to being confined. When they were surrounded with wire netting, although the space inside was ample for all their needs, they squeezed through the meshes, and did so very cleverly when four or five days old. At about this age or earlier they preen their down, and the incipient feathers of the wing, often tumbling over from imperfect co-ordination. They also peck persistently at their toes. They scratch the ground much less than chicks.

More difficulty was found in rearing the pheasants by hand than in the case of chicks. Several died apparently from constipation. None were reared beyond the fifteenth day. The coldness of the season was against them, and unfortunately, through an accident, the incubator drawer in which they slept was allowed to get cold, and this caused the death of the last two, one of which was quite healthy. I hope to repeat the observations, next year, on these and other young birds under more favourable conditions. Such as they are, however, they serve to confirm the conclusions based upon the study of newly-hatched chicks and ducklings, which I briefly set forth in *Natural Science* for March 1894, and which are considered at greater length in my "Introduction to Comparative Psychology," to be published this autumn in the Contemporary Science Series.

C. Lloyd Morgan.

SCHOOLS OF METEOROLOGY.

In your issue of September 13, p. 481, you correctly state that one reason for the small number of meteorologists is the want of a training school. This is a defect in our University curricula that I have frequently pointed out and sought to remedy. You will agree with me that meteorology is worthy of a generous and profound treatment. It should be recognised as a possible major course in all large Universities. Laboratories should be provided where all questions bearing on the atmosphere and its motions can be experimentally elucidated.

I append a sketch of the four years' course of study and work that I hope to carry out with my own students. The necessary laboratory conveniences have not yet been provided, but we are looking forward hopefully.

I shall be glad if your publication of this course contribute in any way to the proper study of meteorology by the young physicists of the British Empire.

Cleveland Abbe.

Washington, September 24.

Columbian University.

Department of Meteorology.

The series of courses in the Department of Meteorology is designed to give a complete review of the present condition of that science, and is therefore necessarily extended through four years; but the series of lectures is so arranged that each of the four divisions is complete within itself; each course presents a view of a branch of the subject such as may be desired by a large number of students who need this information in connection with other branches of knowledge to which they are specially devoting themselves.

Students who intend to take the degree of Ph.D. in meteorology, and who therefore make this the major subject in connection with several other minor courses, must pursue the whole four years' course. Those who desire merely to enter the service of the United States Weather Bureau will probably find the first year's course sufficient to enable them to pass the necessary Civil Service examinations. Those who desire to do work in climatological study should also take the second year. The third year's course is designed for those who wish to perfect themselves in methods of making local weather forecasts. Finally, the fourth year's course will serve as an abundant introduction to the present state of our knowledge of the mechanics and physics of the atmosphere. In addition to the lectures, the instructor will give one hour a week to a quiz-class, in which, by question and answer, he will seek to remove any difficulties that remain.

(1) *Observational Meteorology.*—The methods of observation; the simpler instruments, their errors, corrections, and reductions; the use of self-registers; the forms of record and computation; personal diary of the weather.

Time.—About eighty lectures, or two hours a week, as also eighty other hours of personal investigation of instruments, especially self-registers.

Algebra and trigonometry are necessary preliminaries to this course. Elementary laboratory physics, as illustrated by Hall and Bergen's text-book, is desirable as a preliminary, but may be pursued as a concomitant study. The German language is earnestly recommended as a concomitant. The differential and integral calculus will be needed as preliminary to the Graduate Course in Meteorology.

(2) Climatology, both local and general; empirical meteorology, generalisations, averages, periodicities, irregularities. The relation of climate to geology, to vegetation, to animal life, and to anthropology.

Time.—About forty lectures and four hours weekly given to the investigation of special problems proposed in each lecture.

Students should be familiar with the use of logarithms; the method of least squares; the laws of chance; the details of physical geography, orography, geology, and ocean currents; the physiology of plants and animals; the distribution of species; physical astronomy, especially that of the sun, earth, and moon; terrestrial magnetism; the chemistry of the atmosphere; the biology of atmospheric dust. Physical laboratory work on radiation, conduction, and absorption of heat, and on condensation and evaporation of vapour, and on elementary electricity, is recommended, while German, the calculus and analytic mechanics should be continued as preliminary to the Graduate Course.

Graduate School of Meteorology.

The following scheme of studies in meteorology, subject to arrangement between the teacher and his pupils, is offered for the degree of Doctor of Philosophy:—

(1) Practical meteorology; the daily weather chart; the empirical laws of weather changes as depending on meteorological data, and the arrangement of continents, plateaus, mountains, oceans, &c.; weather types and typical weather charts; prediction of daily weather and seasonal climates; verification of predictions.

Time.—About forty lectures and at least five hours a week additional, in verifying old laws and studying new ones, in making and verifying predictions.

Concomitant Studies.—Methods of chart projection; experimental laboratory work in both steady and discontinuous motions of fluid and gases; mathematical and experimental electricity; the laws of refraction and interference of light; elementary hydrodynamics and thermodynamics; differential equations and definite integrals; the German language.

(2) Theoretical meteorology. Insolation. The absorption, conduction, and radiation of heat by the air and the earth. The thermodynamics of the atmosphere; the graphic methods of Hertz and Bezold. Convective equilibrium, as applied to the atmosphere of the sun by Lane, and to that of the earth by Sir William Thomson

(Lord Kelvin) and his successors. Motion on a rotating globe; Ferrel's and other simple approximate relations between baric gradients and the wind and temperature; Ferrel's general circulation of the atmosphere and his cyclones and pericyclones and tornados. Galton's cyclone and anticyclone. Fourier's most general equations of gaseous motions. Oberbeck's general circulation. Helmholtz's horizontal rolls. The investigations of Diro Kitao, Guldberg and Mohn, Marchi, Boussinesq, A. Poincaré, Sprung, Siemens, Moeller, Ritter, and others into the motions of the atmosphere. Viscosity and discontinuous movements. The possible special solutions of the general equations of fluid motions that apply to the true atmospheric circulation, both on the earth and on the other planets. Atmospheric tides; theories of Laplace, Ferrel, Rayleigh, Margules, A. Poincaré. Theories of atmospheric electricity.

Time.—Eighty lectures and an additional four hours a week given to special reading and investigation, and to the preparation of the final thesis, as closing the four years' course.

Concomitant Studies. — Riemann's "Differential Gleichungen"; Auerbach's "Hydrodynamics"; Lamb's "Fluid Motions" (new edition); physical laboratory work in gaseous motions, optical and electrical phenomena.

THE ROYAL PHOTOGRAPHIC SOCIETY.

SIR H. TRUEMAN WOOD, the new President of the Royal Photographic Society, delivered an address at the opening meeting of the present session on Tuesday. After briefly tracing the development of the Society, he said:

"Turning aside from the consideration of the affairs of our own Society, to the general condition of photography, we find cause for nothing but congratulation. It is not so very long since photography occupied a very subordinate position in the world alike of science and of art. Scientific men looked on photography as a mere art, artists regarded it as a mere science. About twenty years ago, when I suggested that some improvement in a photographic process—I forget now which—ought to be brought before the Physical Section of the British Association, I was told that there was nothing scientific about photography, that it was a mere empirical pursuit, unworthy the attention of serious students of science.

"And to a large extent the reproach was well deserved. Though the list of the earliest workers in photography contains many illustrious names, yet it is true that a large proportion of the most important contributions to photographic knowledge were not made by scientific workers, or by men who worked in scientific methods. They were obtained by practical men, seeking for results; often, indeed, seeking for them successfully by methods which would not have commended themselves to men better equipped with scientific knowledge. Of course this was the consequence of the fact that photographic science was early associated with photographic practice; and the same remark holds good of other sciences, electricity for instance, in which theory and application to practical use advance with equal steps; but I think it applies more to photography than to any other.

"At the present time we have indeed reached a very different condition of things. All the most striking of the recent advances in the science are the result of elaborate scientific research. The most recent improvements in lenses were the fruit of long and laborious investigation into the optical properties and the chemical nature of certain sorts of glass. The increased speed of modern plates, and their improved power of rendering colour values more truly, have only been obtained by minute knowledge of the condition of the problem to be solved, and by careful application of the most recent results of chemical and physical research. If the old photographic crux, the reproduction of colour, has been solved, or, at all events, if a possible method has been indicated for its solution, it was not by haphazard experiment, but by careful adjustment of means to secure an anticipated result. Nowadays, we can only hope for improvement by utilising the advance of scientific knowledge.

"But if the present position of photography is due to progress in the kindred sciences, how amply has she repaid the debt! There is not a single branch of science in which photography is not largely used. There are many whose progress is now absolutely dependent on the power of the camera to observe more accurately, more independently, more minutely, more rapidly, more permanently, than the human eye. If, as appears to be the case, we have reached the limits of human vision, aided by the most delicate instruments that can be constructed, it is difficult to imagine what limits need be set to photographic vision, can we but construct instruments of accuracy sufficient to allow its full powers to be utilised.

"I imagine that the first application of photography to a scientific purpose must have been when Dr. Draper in New York photographed the moon. Whether the pictures he obtained were of any astronomical value, I do not know; certainly those taken a little later, in 1852, by Dr. Warren De la Rue, were, and they were the precursors of the long series of astronomical photographs culminating in Dr. Common's nebula of Orion, and in the great work of charting the heavens by photography which is now in progress.

"The advantages of the 'retina which never forgets,' and it might be added which never tires, which accumulates weak impressions and stores them up till they become one strong one, were long since recognised by De la Rue, and I suppose it will not be very long before, for astronomical purposes, eye observations are entirely superseded by photographic. The photographic camera is now an indispensable adjunct to every large telescope, if indeed it would not be equally correct to say that the telescope is an adjunct to the camera, since the astronomical telescope tends more and more to assimilate to the form adopted long since by Mr. Rutherford, in which the visual rays are treated of but slight importance, and the chief attention is given to the accurate utilisation of the more chemically active rays at the violet end of the spectrum.[1]

"In his recent address to the Photographic Convention at Dublin, Sir Howard Grubb, than whom nobody is better qualified to speak on the subject, dwelt on the services which photography has rendered to astronomy, and gave several striking illustrations of those services. Indeed, if one not qualified to speak on such matters with any authority might hazard an opinion, it would almost seem as if the power of recording observations had already outstripped the capacity for examining the observations, and drawing conclusions from them. When we are told that a photographic plate has recorded 10,000 stars in an area not containing a single visible star, one may be excused an expression of wonder as to how the human mind is ever to grapple with problems of such infinite complexity, to turn to useful account observations dealing with such enormous multitudes.

"But if the telescope has lately become one of the most important of photographic appliances, the spectroscope may be said to have held that position almost since its introduction. Mr. Norman Lockyer, in his well-known text-book, "Studies in Spectrum Analysis," attributes to

[1] A good illustration of the telescope of the future would appear to be the 24-inch photographic refractor with an 18-inch visual telescope, now being constructed at the expense of Mr. McLean for the Cape Observatory.

Sir John Herschel the first suggestion of spectrum photography, and we find that in 1839 the latter pointed out that the way to investigate sensitiveness was to photograph the spectrum. In the following year he read a paper describing his results of spectrum photography. A little later, in 1842, Becquerel and Draper were both at work photographing the solar spectrum. Twenty years later (in 1864) Miller was turning to practical account the power of photography to record the parts of the spectrum beyond the limits of human vision, and from that date nearly all spectroscopic work has been photographic work. Whether applied to astronomical observation or chemical research, the spectroscope has always been combined with the camera, and it is by the combination of the two instruments that such wonderful results have been attained. And as photographic methods have improved, so have fresh facilities been afforded to the spectroscopic worker. Mr. Lockyer's earlier work was of necessity done with wet plates, but with the plates now available he is producing star spectra on a scale comparable with the solar spectra of twenty-five years ago.[1] Rutherford's recent maps of the solar spectrum could not have been produced without the use of colour-sensitive plates, while in one of the most recent attempts to employ spectroscopic analysis for purposes of practical metallurgy[2] Prof. Hartley tells us that he also used orthochromatic plates, specially prepared, and that after trying various developers he found hydroquinone the best.

"As an automatic recorder of scientific observations, photography seems to have been utilised in the Royal Observatory about 1847, under the superintendence of the venerable ex-president of this Society, Mr. Glaisher, who has been kind enough to furnish me with particulars of the methods originally devised by Mr. Charles Brooke, and successfully worked for many years by Mr. Glaisher and his staff.

"The method was first applied to record magnetic variations and the movements of the barometer and thermometer. In the case of the former, a ray of light reflected from a mirror carried by the magnet was focussed on the surface of a cylinder covered with sensitised paper.[3] The cylinder was rotated by clockwork, the result being, of course—in the way now commonly employed for such automatic records—to give, when the image was developed, a record of the movements of the magnet. A base line was given by an invariable spot of light, and by intermissions of this light a time record was provided. Similar results were obtained in the case of the barometer by using a float with a small perforation through which the light passed, and with the thermometer by simply allowing the mercury itself to screen the light from the sensitive surface.[4]

"Later on, in 1865, similar means were used by Mr, Glaisher for the automatic record of earth-currents, and they have consequently been continuously observed since that date at Greenwich.

"To the best of my knowledge but little alteration has been made in the original system, the only improvement being in the sensitive surface employed. When gelatino-bromide paper was introduced, it was tried and adopted at Greenwich, and by its means superior results were obtained.

"I have ventured to dwell at some little length on this part of the subject, not because what I have said can be novel to any of you, but because I think this first application of photography to automatic observation has considerable historical interest, and also because this application was carried out by one so long and so honourably connected with this Society.

"The principle thus first applied at Greenwich has received numerous other applications, and indeed it is now a matter of course that photographic methods should be used to register the movements of any instrument of whose indications it is desired to preserve a record. Instances are of course numerous in which no other method is possible. Hardly any but a photographic method could register the movements of the light spot of a reflecting galvanometer, and thus enable the physicist who, like Langley, is measuring the heat radiated from celestial bodies, to record the minutest differences of temperature; the chemist, like Dewar, who is producing hardly imaginable cold, to record temperatures approaching absolute zero; the metallurgist, like Roberts-Austen, who is dealing with the melting points of metals, to register by a photographically traced curve variations in high temperatures which but a short time ago could not be accurately measured at all. It is interesting to read the testimony of the last named, given at the recent conference of the Camera Club, to the effect that he could not conceive of any method which would give such results in the same space and time. Equally interesting is it to note the Professor's suggestion for a practical method of recording continuously the temperature of the air-supply of a blast furnace, a matter of great importance to the iron manufacturer, of which he says:—'If we had no photography it would be impossible to get a record which would be anything like so true.'

"Numerous other instances will occur to many of you in which photography has been or might be—indeed I may say will be—applied to similar purposes. I will only refer to one, because it appears to me so excellent an instance of the delicacy of the method. At the last (the Oxford) meeting of the British Association, Mr. Burch showed to the newly-formed Physiological Section photographic records taken with the aid of the capillary electrometer of electrical currents produced by speaking into the telephone. The letter *z* produced a complicated curve in which oscillations of current lasting only 1/3000 sec. were visible with a lens.

"It seems hardly worth while to trouble you with the details of many of the other services which photography has rendered to science, and if I were to attempt to produce an exhaustive list, there are many present to-night who could supplement it out of their own knowledge. The meteorologist has been enabled by its aid to study the form and nature of clouds, the shape and character of the lightning flash. The zoologist has been taught much about animal motion. The microscopist has long learnt to rely on the camera as the only accurate means of reproducing the objects of his studies. The physicist has by photographic methods investigated many phenomena in which the changes are too rapid for the human eye to follow them. By such means Lord Rayleigh and Prof. Boys have obtained long series of pictures of occurrences which all took place within a fraction of a second, thus almost analysing time as the chemist analyses matter.

"The uses of photography in ethnology, geology, geography, natural history, archæology, are too obvious to need mention. They and many other applications may be summed up in the remark that whenever the observer of natural phenomena requires to make an accurate record of his observations, photography supplies the means. It also supplies the means of showing to a room full of spectators what could otherwise be seen by but a single observer at one time, and has thus rendered to the popularisation of science no less a service than it has lent to its advancement. This universal use of photography for purposes of demonstration must certainly not be forgotten in however brief a summary of its applications."

[1] "Photographic Spectra of some of the Brighter Stars." *Phil. Trans.*, vol. 184 (1893), A., p. 675 *et seq.*

[2] "Flame Spectra at High Temperatures." *Phil. Trans.*, vol. 185, A., p. 161 *et seq.*

[3] The method employed was a form of the old calotype process. Paper treated with potassium bromide and iodide was afterwards sensitised with silver nitrate. The development was by gallic acid.

[4] For a full account of the apparatus reference may be made to an addendum to the introduction to the Greenwich magnetical and meteorological observations for 1847.

The services of photography to art were next touched upon by Sir H. T. Wood, who afterwards went on to say:

"The interesting investigations of Buchner and Marshall Ward into the action of light on bacteria can hardly with justice be admitted as adding to the list of photographic materials, though we must certainly claim the 'photobacteriograph' as an advance in our science and as suggesting new directions for photographic work.

"The question of sensitometry has exercised the minds of many of our most active workers for some time, but I think I may say without as yet any positive result. I believe I may put it as the opinion of those best qualified to express an impartial judgment on the subject, that while we have certainly obtained a means of roughly gauging the comparative sensitiveness of plates, and have got a guide of great practical use to the makers and users of plates, we are as far as ever from an absolute standard, and that the attainment of such a standard must await the attainment of a standard of light, a problem the solution of which is of importance not to photographers alone.

"It would obviously be unreasonable to expect that the increase of photographic knowledge should grow *pari passu* with the number of those who practise the art, but I think it is certainly a matter for regret that of the many thousands who have taken up photography as a pastime, so very few pursue it in a serious way, or in a scientific spirit. The popularisation of photography has indeed to my mind been a drawback to real progress. The process of picture-making has been rendered so easy that it has been deprived of much of its interest, even to the merest amateur in science, and the attention of those who might have pursued photography seriously has been diverted to other branches of science. Still we are fortunate in having, even among the younger workers, a considerable band of capable and active students who are adding slowly but surely to our knowledge of the scientific principles of the art.

"In photographic optics there is, I think I may say, a very distinct advance now going on. The expectations of opticians have long been fixed on the productions of the Jena manufactory, and those expectations are, according to the best information at my disposal, now in a fair way of being realised. The qualities of glass that are to be obtained commercially from Jena have provided the opticians with new possibilities for the improvement of photographic lenses. Both in this country and in Germany opticians are availing themselves of these possibilities. Great credit is certainly due to Messrs. Ross, who have carried out the work of Dr. Schroeder, and have produced from his calculations the lens which they have termed the 'concentric' lens. The double anastigmat of Goerz, described last year to the Society by that gentleman, is another new lens, the outcome of the Jena improvements in giass, which ought at least to receive mention.

"Mr. Dallmeyer has also made considerable advances, both theoretical and practical, in his 'telephotographic' lens, an instrument which produces results appealing at once to all who take any interest in photographic matters, and one which, in the opinion of competent authorities, is likely to have important practical applications for astronomical and other branches of scientific photography."

WILLIAM TOPLEY, F.R.S.

A GREAT gap has been made in the ranks of active geologists by the death of William Topley, which took place on the night of Sunday, September 30, at his house at Croydon. He was taken ill, with gastritis, probably from the use of contaminated water, in Algiers, during a short visit, made in reference to its geology; and he fell, therefore, in the fighting line of those who apply their scientific knowledge for the good of mankind.

He was ill whilst travelling home, and though after a time he began a slow recovery, a relapse came on Saturday, September 29, which soon proved fatal.

Born at Greenwich in 1841, he had reached an age when, though the physical powers may have begun to wane, yet the mental powers are reinforced by stores of knowledge and of experience, and the value of a scientific life is high.

His scientific education was at the Royal School of Mines, Jermyn Street. Soon after his student-life was ended, he joined the Geological Survey (early in 1862), and his future career was identified with that Survey, of which he was one of the oldest and best-known officers at the date of his untimely death.

For many years his work lay in the counties of Kent, Surrey, and Sussex, in the investigation of the great district of the Weald and its surroundings, with which his name will ever be linked.

He made his mark as a good observer of facts and an able reasoner from them in 1865, by the paper, read to the Geological Society, "On the Superficial Deposits of the Valley of the Medway, with Remarks on the Denudation of the Weald," which was written jointly with his then colleague, Dr. C. LeNeve Foster. This is a most important essay, in which the general question of inland erosion is discussed, and the special question of the processes of denudation that had acted over a definite tract, on which much had been written, may be said to have been practically settled, an achievement of no small merit.

In 1866 Mr. Topley supplemented his knowledge of our Wealden deposits by a visit to the Boulonnais, a tract that really contains the severed eastern end of the Weald, a visit in which the writer had the pleasure of accompanying him, and the results of which were given to the Geological Society in 1868.

He soon turned his attention to the bearings of geology on other branches of knowledge, and in 1871 the Royal Agricultural Society published a paper by him, "On the Comparative Agriculture of England and Wales," followed, in the next year, by another, "On the Agricultural Geology of the Weald."

In 1873 a paper was printed by the Anthropological Institute, in which he treated of the relation of parish boundaries to great physical features. This was illustrated chiefly from parts of the Weald and its borders; but references were made to other parts, and amongst them to Northumberland, to which county he had been transferred from the south.

In 1874 he gave the Geological Society a very suggestive paper "On the Correspondence between some Areas of Apparent Upheaval and the Thickening of Subjacent Beds," in which he pointed out that an apparent dip (over a large tract) may be partly owing to the thinning of beds underground.

In 1875 appeared the work by which he will probably be best known, and in the writing and compiling of which he may be said to have raised his own monument. The Geological Survey Memoir on the Weald is noted, not so much for local details (of which, however, there are many) as for the thorough way in which the literature of the subject is treated, for the full discussion of the subjects of physical geology, scenery, and denudation, and for the attention given to many branches of applied geology. The parts mentioned indeed take up more than half of the text, adding greatly to the interest of the book.

Naturally the important work of the Sub-wealden Boring was not done without Mr. Topley's help.

In 1876, he used his northern experience in the field in joining his friend Prof. Lebour in a paper to the Geological Society, on the intrusive nature of the Whin Sill, published the following year.

Since that time he contributed papers to various societies, other than those already mentioned, and to various journals. These are chiefly on questions relating to economic geology, such as water-supply, petroleum, and coal in south-eastern England; and are too many to be noticed here. His name also appears, of course, as author, or part author, on many sheets of the maps and sections of the Geological Survey.

It is not only, however, by his published works that Mr. Topley is known—in science his was a public life. He took a marked part in the work of the British Association, and was secretary of its Geological Section for no less than fifteen years—one of the longest of such secretarial lives. He also served on some committees, and was secretary of that on coast erosion, the reports of which owe much to him. He served on the councils of the Geological Society and of the Geologists' Association for many years, and was president of the latter body for two years (1885–7). He took part in most of the international geological congresses, and worked hard for the great one in London, of which he was a secretary, in 1888. He was also for some time a sub-editor, and afterwards editor, of the *Geological Record*.

In his latter years, his presence at the Geological Survey Office, for a period of about fourteen years, brought him into contact with many people, who benefited by his knowledge and by his readiness in imparting it. Amongst engineers and others he was widely known as an expert of the most trustworthy kind on questions of water-supply, and of other subjects in which geologic knowledge comes in.

Happy in his domestic relations, of a kindly, cheerful disposition, good-natured and hospitable, he was always ready to help his brethren of the hammer, as well as all those who went to the Survey Office for information; indeed, a former colleague has said of him, to the writer, that his one prominent fault was excessive amiability.

He will be greatly missed by his colleagues, and his loss will be felt over a much wider circle—in fact, by all who knew him. W. W.

NOTES.

Two letters of Charles Darwin are published for the first time in the *Bulletin* of the Royal Botanic Gardens, Trinidad, No. 22, April 1894. These letters were addressed, before the completion of Darwin's book on the fertilisation of orchids, to the late Dr. Herman Cruger, who was Government Botanist at Trinidad for some years, asking him to observe if possible the fertilisation of certain species of the Melastomads. In the first letter he expresses a suspicion that the flowers which have the singular projections, or horns from their anthers, may be visited by small insects which penetrate one of the horns of the anther with their proboscis, to obtain the fluid contained in them. In the second letter he admits that this suspicion is quite groundless, and asks for information with regard to any instances of "bud-variation" in plants from the warmer regions cultivated in the West Indies.

THE Botanical Society of America is about to try the experiment of admitting working naturalists only to its full fellowship. By a unanimous vote the Society has adopted a new constitution providing that none but American botanists engaged in research, who have published work of recognised merit, shall be eligible to active membership. Candidates for active membership must be recommended by three active members of the Society, but any nominee may be objected to by any member, and if ten members object, the name will not be considered by the Council. Nominees may be rejected by two negative votes in the Council, which numbers seven members, or by one-fifth of the votes cast after the name has been approved. The President of the Society for the present year is Prof. W. Trelease; the Vice-president, Prof. N. L. Britton; the Secretary, Mr. C. R. Barnes; the Treasurer, Mr. J. Donnell Smith.

DR. T. LAUDER BRUNTON, F.R.S., will deliver the annual Harveian oration at the Royal College of Physicians, on Thursday, October 18, at 4 p.m.

TWO new wings of the Durham College of Science were inaugurated on Tuesday. The wings include apartments to be devoted to the study of engineering and the fine arts.

ON Friday last, the Duke and Duchess of York opened the new medical school, erected at a cost of £40,000, in connection with the Yorkshire College, Leeds, and also a new central hall and library, which have been added to the College at a cost of £20,000.

THE Essex Field Club will hold its annual cryptogamic and botanical meeting on Saturday, October 13. The head-quarters for the meeting is the "King's Oak" Hotel, High Beach, Epping Forest.

THE opening meeting of the Royal Microscopical Society will take place on Wednesday, October 17, at 8 p.m., when Mr. F. Chapman will read a paper "On the Foraminifera of the Gault of Folkestone"; and Dr. H. Stolterfoth will give some notes on the genus *Corethron*.

A MEETING of the Institution of Mechanical Engineers will be held on Wednesday evening, October 24, and Thursday evening, October 25. The following papers will be read and discussed, as far as time permits:—"The Manufacture of Standard Screws for Machine-made Watches," by Mr. Charles J. Hewitt (Wednesday); "Drilling Machines for Cylindrical Boiler Shells," by Mr. Samuel Dixon (Thursday).

IT is reported that a violent storm passed over the town of Little Rock, Arkansas, at the beginning of last week. Though the storm or tornado only lasted three minutes, eight persons were killed during that time, and several were seriously injured, while property was damaged to an amount estimated at £200,000. The direction of motion of the disturbance was from south-west to north-east, and the width of the path traversed was only about two hundred yards. The storm was accompanied by heavy rain, and was followed by brilliant lightning.

ONE of the most valuable and extensive botanical libraries in the country, that collected by Prof. Lindley, has been for many years deposited in the rooms of the Royal Horticultural Society, under the care of trustees. It is now proposed to increase the value of the Lindley Library by forming, in connection with it, a library fund, to be administered by the trustees in connection with the Council of the Royal Horticultural Society. The money would be expended in cataloguing the library, and in the purchase of new books, for which the income at present at the command of the trustees does not suffice. Donations of horticultural and botanical works are also desired.

THE Berlin correspondent of the *Times* reports:—"The death is announced of Prof. Pringsheim, the well-known German botanist, at the age of seventy-one. As early as his thirty-third year he was elected member of the Berlin Academy of Sciences in appreciation of his researches and writings, which dealt especially with the processes of fructification and germination in the family of the Algæ. From 1864 to 1868 he filled the post of Professor of Botany at Jena, where he founded the first Institute for Vegetable Physiology, and this example was soon followed in other parts of Germany. Prof. Pringsheim returned to Berlin in 1868 and established a private laboratory, in which he carried out valuable investigations on the sexual life of the lowest vegetable organisms."

MR. H. J. MACKINDER commenced a course of lectures on the History of Geography and Geographical Discovery, at Gresham College, on Monday evening. The course, which will consist of twenty-five lectures, has been arranged for jointly by the Geographical Society and the London Society for the Extension of University Teaching.

PROF. RICHTER, of Graz, has been engaged for some time in making a careful bathymetrical survey of the Lake of Garda. By the use of an unusually light and compact wire-sounding machine he has been able to obtain rapid soundings, even in the greatest depths (364 metres) with a lead weighing only 800 grammes, and he is preparing a contoured map of the lake-basin.

EFFORTS were made this summer by several expeditions to ascertain the fate of the Swedish naturalists, Björling and Kalstennius, but no information has yet been received. The *Falcon* called at the Carey Islands, Clarence Head, and Cape Faraday, but found no trace of the unfortunate young men, while the most careful inquiries amongst the Eskimos of the Greenland coast elicited no news. There is no farther probability of their survival.

THE Arctic exploring parties at work during the season just past have not been by any means so successful as might have been expected. The weather seems to have been exceptionally unfavourable, and to have greatly hampered the movements of even the best equipped and most experienced Arctic travellers. Lieut. Peary has not felt justified in returning to America, although Mrs. Peary and her baby came back in the ship sent for their relief. Mr. Peary started on his main journey, after wintering at Bowdoin Bay, on March 6, with eight men, twelve sledges, and a large number of dogs. The cold encountered was very great, the thermometer falling to – 60° F., and very high wind was occasionally experienced. The expedition pushed on for twenty-seven days in the direction of Independence Bay, but only succeeded in travelling 220 miles when the death of most of the dogs from cold, and the disablement of some of the men, made it necessary to return, and Bowdoin Bay was regained on April 18. Thus Peary was unable even to reach the starting-point he had fixed upon as the base whence to push northward, and he had to content himself with making a detailed survey of Bowdoin Bay and the neighbouring coast of Inglefield Gulf during the summer. The *Falcon* arrived to his relief on August 20, and after landing a year's provisions, left him determined to make another resolute attempt to reach the new land beyond Independence Bay next spring.

THE Report of the Australian Museum, Sydney, for the year 1893, shows that the Government retrenchment scheme has caused the museum to suffer severely. There have been no funds to purchase specimens, nor to publish the results of investigation. At the commencement of the year there were thirty-three officers and workmen on the staff, but owing to the necessity for retrenchment twelve of these were discharged, and the salaries of most of the others were reduced by amounts varying from £5 to £50. The amount voted for the ordinary service of the museum in 1892 was £7150, while in 1893 it was reduced to £3862. The trustees point out that it will be difficult to carry on the institution efficiently out of the reduced vote. It appears that in the parts of the museum open to the public, there are not hands enough now to keep the outside of the cases free from dust, although the specimens in them are duly cared for, and are in good order; the windows have not been properly cleaned for months, and the grounds are being over-run with weeds. Dr. E. P. Ramsay has recently retired from the directorship, owing to ill-health, and has been succeeded by Mr. R. Etheridge, jun.

PROF. A. KLOSSOVSKY, director of the observatory at Odessa, has published an interesting paper on the annual distribution of thunderstorms over the globe, accompanied by a coloured map showing their intensity in different localities. The question has hitherto been but little studied, as it is necessary to have a long series of observations in order to arrive at satisfactory mean values. He points out that a high temperature, a certain degree of humidity, and a considerable amount of rainfall, are the principal agents which favour the development of thunderstorms. The map shows that a zone of electric activity of great intensity exists on both sides of the equator, and this is also the zone of greatest rainfall. This zone is divided into three sections: (1) That embracing Asia and Oceania, Indo-China and the Sunda Isles to New Guinea, the yearly average amounting to ninety or one hundred storms. (2) The zone starting from the west coast of Africa, between 5° and 10° N. latitude, and 10° to 15° S. latitude. (3) The tropical regions of America, where the mean annual number of storms exceeds one hundred between 20° and 22° N. latitude. To the north of the zone which he terms the electric equator the number of storms decreases, we reach the deserts of Africa, Egypt, Persia, and Central Asia, where rainfall is scanty. To the north of the zone of deserts, especially over the continents of Europe and Asia, the electric activity is somewhat increased. For the high latitudes of the southern hemisphere, the principal data refer to the Falkland Islands, where the average number of storms is four. The sketch is necessarily very imperfect, but the subject is worthy of consideration and further investigation; and the author points out that, in his opinion, the solution of many meteorological phenomena is connected with atmospherical electricity.

A BRIEF account of the great Constantinople earthquake of July 10 has been already written by M. D. Eginitis, director of the Observatory of Athens (*Comptus Rendus*, vol. cxix. pp. 480-483). It occurred at 12h. 24m. p.m. Constantinople mean time. The earthquake consisted of three violent shocks, separated by very short intervals, and lasting altogether seventeen to eighteen seconds. The first and slightest was horizontal; the second, by which most of the damage was done, vertical and rotatory; and the third, undulatory and towards the end horizontal. The epicentral area, that of greatest damage, is in the form of an elongated ellipse; the major axis is 175 km. long, and extends from Tchatalıza to Ada-bazar along the Gulf of Ismed; the minor axis is situated between the villages of Katirly and Maltépé, at the mouth of the gulf, and is 39 km. in length. At all parts of the epicentre the three shocks had approximately the same direction, nearly perpendicular to the major axis. The intensity was greatest in the islands of Halki and Antigoni. The fissures are few in number, the most important being at Ambarly, a village built on alluvial soil. This one is 3 km. long, 0·08 m. in maximum breadth, and runs east and west, *i.e.* parallel to the neighbouring sea-coast, which is 300 m. distant. The Kartal-Dardanelles cable was cut in several places, as if by a knife. The sea was greatly agitated along the epicentral coast. In some parts, it was observed to retreat for about 200 m., and after some oscillations to return to its normal condition. The depth of the seismic focus was found by Dutton and Hayden's method to be 34 km., and this agrees closely with the value obtained by M. Lacome from the observed times of the shock at different places. The shock travelled to Paris, Pavlovsk and Bucharest, with velocities of 3, 3·5 and 3·6 km. per second, respectively (see NATURE, vol. l. pp. 450-451).

THE *Zeitschrift für Instrumentenkunde* contains some particulars of the new method, adopted by Signor G. Guglielmo, for the exact measurement of differences of pressure. Instead

of enlarging the displacement of the mercury column in the manometer or barometer by means of a capillary filled with oil, or containing an air-bubble, the new method is based upon the principle of readjusting the level to a fixed mark by the addition or subtraction of mercury, the quantity added or subtracted being weighed or measured with a burette. If the sectional area of the burette is one-hundredth of that of the manometer tube, a displacement in the former of 1 mm. will indicate a difference of pressure of 0·01 mm. To make the method sensitive it is best to use water as the manometer liquid, and to add or subtract mercury, which is more easily measured. The chief desideratum is a simple method of adding or subtracting, which is best done by attaching a sucking-tube to the top of the burette. A pointer is fixed inside the manometer tube opposite the centre of the meniscus. By observing the reflection of the pointer in the surface, and the depressions or elevations produced by the pointer, the observer is able to fix upon the mark to within 0·001 mm. If mercury is used, an electric contact is desirable. For barometer readings, pointers can be mounted in both branches of the tube, and measurements taken for both. Signor Guglielmo has also constructed an absolute electrometer based upon this principle, in which the level of mercury in a flat dish communicating with another is disturbed by a charged disc, and readjusted by adding or subtracting mercury.

WE have received from Dr. Luigi Palazzo, of the Meteorological Office at Rome, an account of a small portable unifilar magnetometer which he has designed, and which is being employed in the study of local magnetic disturbances in Italy. Signor Palazzo does not claim any special novelty in the general design, which in many respects resembles the Kew form of portable unifilar. The instrument is designed for observing the declination and horizontal force at strings of stations at one of which the elements have been determined by means of one of the more accurate and cumbersome forms of instrument. For the purpose in view it was of importance to have an instrument which should combine extreme lightness with portability, so that the different sets of observations along a line of stations might be quickly taken, and thus, to a certain extent, the effects of disturbances minimised, since there does not seem to be a self-recording magnetograph in the district under investigation, from the photographic records of which the disturbances could be eliminated. The azimuth circle has a diameter of 8 cm. and carries the graduations on the rim, a method of graduating the circle which, unless the tripod is very high, and therefore unstable, renders the reading of the verniers a matter of difficulty. The magnet employed is a hollow cylinder, as in the Kew instrument, carrying a photographic scale at one end and a lens at the other. The mirror which is used for illuminating the scale, as well as for reflecting the rays of the sun when determining the geographical meridian, is composed of a piece of parallel-sided plane unsilvered glass mounted on trunnions which are carried in V's of the ordinary form. The whole instrument packs into a box 28 × 12 × 18 cm. and only weighs four kilograms. The author does not say with what accuracy the horizontal component can be measured, but from some figures given it would appear that the declination can be determined to within about three minutes of arc; which, considering the small size of the instrument, is remarkably good. In order to facilitate the measurement of the bearing of landmarks, the telescope is supported on horizontal trunnions, so that it can be tilted in a vertical plane about 10° on either side of the horizontal.

THE "Proceedings of the Royal Physical Society of Edinburgh," Session 1893–94, is now ready, and may be purchased at the Society's rooms, George-street, Edinburgh.

PROF. J. SHIELD NICHOLSON'S lecture on "Historical Progress and Ideal Socialism," delivered at the Oxford meeting of the British Association, has been published in handy volume form by Messrs. A. and C. Black.

WE learn from the *Journal of Botany* that the monograph of the Mycetozoa, on which Mr. Arthur Lister has been engaged for some years, founded on the collection in the herbarium of the British Museum, will shortly be published.

UNDER the title "Nomenclator Coleopterologicus," H. Bechhold, of Frankfort-on-Maine, has published, for Herr S. Schlenkling, an etymological index, together with a list of species and their varieties, of the beetles of German districts. The book should be extremely useful to students of Coleoptera.

MR. BERNARD QUARITCH, Piccadilly, has issued a list of choice and valuable books he has for sale, including the library of the late Warren De la Rue. Many important works on physics, chemistry, astronomy, electricity, mathematics, photography, and microscopy are contained in the catalogue.

WE have received from the Skandinavisk Antiquariat, Copenhagen, a catalogue of books, ancient and modern, of Iceland and Scandinavia, which they have for sale. The catalogue, which will be sent free to all applicants, contains particulars of books relating to bibliography, periodical literature, the languages of the north, runology, mythology, archæology, topography, &c.

CHILL October has come, and with it a new number of "The Country Month by Month," in which Mrs. Owen and Prof. Boulger describe the characteristics of the plant-world and bird-life during the month. The entomologist's main occupation in October is digging up subterranean pupæ, so the authors give a brief account of insect metamorphosis. The chapter on bird-life deals with the autumnal migration of our birds in a very interesting manner.

THE Zoological Society of Germany has conferred a great boon upon students of natural history by editing a reprint of the tenth edition of Linnæus' "Systema Naturæ." The first volume, dealing with the animal kingdom, has lately been published by Wilhelm Engelmann, Leipzig. It is well printed, and will be very acceptable to those who are not the fortunate possessors of a copy of the original tenth and standard edition of Linnæus' work.

THE sixteenth edition of their "Catalogue of Minerals and Mineralogical Subjects" has been issued by Messrs. G. L. English and Co., New York. The illustrations are all new, and a complete revision of all Messrs. English's systematic collections has been made. The species are classified according to Dana's new "System of Mineralogy" (1892). The index to the catalogue is particularly valuable, for it enumerates all species, and refers to the proper species all important synonyms and varieties.

A REMARKABLE new substance, obtained by the action of ordinary alcohol upon peroxide of sodium, is described by Prof. Tafel in the current *Berichte*. When alcohol is poured upon sodium peroxide, about half of the latter disappears to form a strongly alkaline solution which contains practically no active oxygen, while the remaining half undergoes a complete change. The pale yellow colour of the commercial peroxide becomes changed to pure white, and the substance assumes the nature of a fine granular powder, totally different from peroxide of sodium. This substance is soluble in water, but with much less rise of temperature than the peroxide. While the latter compound is stable up to a high temperature, evolving no oxygen when pure below red-heat, the new substance evolves large quantities of oxygen upon gently warming, and if rapidly

heated in a tube closed at one end explodes with violence and production of flame. The powder behaves very curiously if touched in one place with a heated rod; the particles are set in rapid whirling motion by the escaping oxygen, and the rise of temperature is so great as frequently to terminate in local combustion. This unusual phenomenon gradually extends throughout the whole mass, oxygen being copiously and continuously evolved in an almost perfectly dry state. When much more strongly heated the substance melts and then evolves water vapour, the residue consisting of ordinary sodium hydrate. Analyses indicate that the substance possesses the composition $HNaO_2$. Its production from sodium peroxide and alcohol in all probability occurs in accordance with the following equation, sodium ethylate being the secondary product:

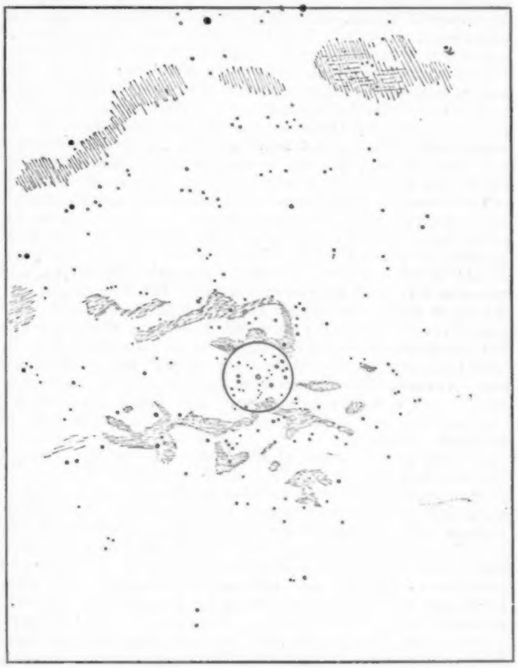
$$Na_2O_2 + C_2H_5OH = C_2H_5ONa + HNaO_2.$$

The probable existence of this new sodium compound was pointed out by Prof. Tafel in a previous communication concerning the action of alcoholic mineral acids upon sodium peroxide, and he has now been able to isolate it. He considers it to be the hydrate of a trioxide of sodium Na_2O_3. It dissolves in ice-cold water without decomposition, but at temperatures very little higher the solution slowly evolves oxygen. If alcohol is added to this solution the evolution of gas is considerably augmented and the solution deposits after some hours crystals of Mr. Vernon Harcourt's hydrate of sodium peroxide, $Na_2O_2.8H_2O$. Hydrochloric acid converts it into sodium chloride, hydrogen peroxide, and gaseous oxygen. In order to prepare the new compound, twelve grams of sodium peroxide and two hundred cubic centimetres of ice-cold absolute alcohol are convenient quantities to take; they should be well shaken together in a closed flask, the liquid and the fine white sandy product separated from any undecomposed lumps of peroxide, rapidly filtered, the white sand-like substance washed with cold alcohol and ether, and stored in a desiccator.

THE additions to the Zoological Society's Gardens during the past week include a Diana Monkey (*Cercopithecus diana*, ♀) from West Africa, presented by Mrs. Collcutt; a Mozambique Monkey (*Cercopithecus pygerythrus*, ♀) from East Africa, presented by Mr. H. J. Clowes; a Macaque Monkey (*Macacus cynomolgus*, ♂) from India, presented by Mrs. Morris; a Leopard (*Felis pardus*) from East Africa, presented by Mr. Thomas E. Remington; a Two-spotted Paradoxure (*Nandinia binotata*) from West Africa, presented by Dr. Sydney W. Thompstone; a Moose (*Alces machlis*, ♂) from Sweden, presented by Mr. Guy Nickalls; a Bennett's Wallaby (*Halmaturus bennettii*, ♂) from Tasmania, presented by Captain G. W. Brook; two Horned Screamers (*Palamadea cornuta*) from Para, presented by Mr. H. A. Astlett; a Banded Parrakeet (*Palæornis fasciatus*, ♀) from India, presented by Mr. Thomas Hodgson; a Green Turtle (*Chelone viridis*); a Hawks-billed Turtle (*Chelone imbricata*) from the East Indies, deposited; a Mexican Guan (*Penelope purpurascens*) from Central America, two American Wigeon (*Mareca americana*) from Brazil, a Short-tailed Parrot (*Pachyrus brachyurus*) from the Upper Amazon, purchased; two Raccoons (*Procyon lotor*); a Persian Gazelle (*Gazella subgutterosa*, ♂), born in the Gardens, three Bar-tailed Pheasants (*Phasianus reevesii*), an Amherst Pheasant (*Thaumalea amherstiæ*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

NEBULOSITIES NEAR THE PLEIADES.—For many years, says Prof. E. E. Barnard in the *Astronomische Nachrichten*, No. 3253, he has known of a vast and extensive nebulosity north of the Pleiades. This is not to be confounded with the nebulosities round the cluster revealed by photography during the last ten years, and all of which are included within the circle on the accompanying illustration. The wisps and patches of nebulous matter outside the circle are shown upon a photograph taken by Prof. Barnard with the Willard lens which he has rendered famous, the plate being exposed for ten hours, fifteen minutes.



The curved and streaky streams of celestial mist in the illustration are apparently connected with the Pleiades, though some of them extend irregularly for several degrees each side of the cluster. Prof. Barnard hopes to obtain still clearer pictures of the nebulosities by extending the time of exposure.

SCIENCE IN THE MAGAZINES.

EAST and west, as everyone knows, are merely relative terms. Elisée Reclus, in the *Contemporary*, traces the normal line of separation between the two halves of the ancient world which best deserve these names, considering the matter from an historical point of view. The true and natural partition between east and west of the ancient world is a transverse zone running from north to south between the Arctic Sea and the Gulf of Oram. This almost uninhabited zone begins just west of the plains of the Lower Indus, in the desert tracts of Lower Beluchistan, and ends in the barren reaches between the Obi and the Yenisei. Such a zone divides the world into two halves having continental masses of nearly equal size. The evolution of humanity was worked out differently on the two sides of this line, and the two developments are traced in the article referred to.

A very exhaustive article is contributed by Mr. John Rae to the same review, under the title "The Work of the Beer Money." The author describes what the County Councils have done for technical education since the passing of the Local Taxation (Customs and Excise Act) of 1890, when funds for the purpose of furthering such instruction became available. To those who expected great things, the survey will be disappointing; for it shows that in many cases the moneys have been expended almost uselessly. Better results, however, could hardly be expected, for it must be remembered that the County Councils had to create the machinery with which to carry on the work. On this account many mistakes have been made, "but," says Mr. Rae, "they [the Councils] have gone about matters in a practical way, and when they have made mistakes they have shown themselves quick to repair them. Much of the

work was necessarily tentative, and that indeed is part of its value. Each local authority has started the work in its own way, according to its own circumstances, industries, and resources; so that the country has for two years been one great experimental station, with some hundreds of separate plots of educational varieties." The sums spent upon the erection of important technical schools during the last six or seven years will astonish many people. To quote Mr. Rae: "Bolton has built a technical school at a cost of £15,000; Bury, at a cost of £16,000; Blackburn, of £40,000. Oldham and Rochdale are now spending £12,000 each in building one; Halifax and Derby are spending £20,000 each; Bath, £21,000; Worcester and West Ham, £40,000; Birmingham, £48,000; and Manchester, on a site worth £100,000, is erecting a technical school estimated to cost £130,000 more, the most elaborate and magnificent product of the whole movement." So far as we can gather from the article, the work which has been done shows good promise of practical fruit. It is pointed out that the grant should be secured permanently for education by statute, and this should be done as soon as possible. Mr. Rae thinks that the worst deficiencies which the experience of the past three years has revealed are (1) the startling illiteracy of the men and the lads who have passed the standards of elementary schools, and (2) the general want of the means of good secondary education. These are the deficiencies which must prevent the effectual diffusion of technical instruction. Mr. Rae's article should certainly be read by everyone interested in the progress of technical instruction.

Another article in the *Contemporary* is entitled "Joseph Priestley in Domestic Life," by Madame Belloc. The mother of the authoress was taught to read by Priestley, and she gave her daughter a very clear idea of his personality. The article thus contains a description of the investigator as he really was according to the last echo of oral tradition. And though it deals chiefly with Priestley's private life, students of the history of chemical science will find parts of it interesting. The *Contemporary* also contains an article by Mr. Herbert Spencer, whose theme is "Weismannism Once More." Mr. Spencer harks back to the original points of discussion between Prof. Weismann and himself, in order to show (1) that certain leading propositions having been passed by unnoticed, remain outstanding; and (2) that when leading propositions have been dealt with, the replies given are invalid.

In the *National Review*, Mr. F. W. H. Myers writes on "The Drift of Psychical Research." Wonderful things are told of telepathy and kindred powers, and the author is very sanguine as to future developments. He recognises that men of science fight shy of the "glum researches," and are ever ready to put their fingers upon the weak points in psychical reasoning and investigation. This dislike is accounted for by the rude approximate character of the work carried on by its votaries; but, on the other hand, Mr. Myers holds that psychology is a new science, and has, therefore, to grope its way up to the exactness of older branches of knowledge. He inclines to the opinion that the methods of science cannot at present be extended to the realm in which he is an explorer. After Mr. Myers' article, and as an antidote to it, one contributed by Mr. Ernest Hart to the *Century* should be read. Mr. Hart's paper should convince every even-minded person of the imposture widely practised under the names of hypnotism, spiritualism, telepathy, "spookism" in its various manifestations, Mahatmism, Matteism, and other phenomena of an occult character. The same magazine contains the conclusion of the series of articles, "Across Asia on a Bicycle," contributed by Messrs. T. G. Allen and W. L. Sachtleben; and Mrs. C. L. Franklin gives a short biography of Sophie Germain, whose mathematical works and philosophical writings gained for her such a high reputation at the beginning of this century.

Sir Robert Ball continues his articles on "The Great Astronomers," in *Good Words*, the subject this month being Galileo. He handles the matter of Galileo's trial for heresy very carefully, and does not give vent to the feelings which every astronomer must experience when describing the events which led up to the abjuration which the founder of physical astronomy was forced to pronounce. Mr. T. Munro combines imagination with science in an article, "Sun-rise or the Morn," in *Cassell's Family Magazine*. The Mammoth Cave of Kentucky is the subject of an article, by Prof. W. G. Blaikie, in the same magazine. Under the alliterative title, "Seers of Science," Mr. Munro shows, in the *Leisure Hour*, how poets and story-tellers have anticipated some of the discoveries of science. It would have been strange if, in all the vague speculations which have been given to the world, some coincidences of the kind referred to had not been found. Salt, and sleeplessness are the subjects of two other articles in the *Leisure Hour*.

An extremely interesting account of "Tarahumari Dances and Plant Worship" is given by Dr. Carl Lumholtz in *Scribner*, with illustrations from photographs by the author. Another article of ethnographical importance is "Customs connected with Burial among the Sihanaka," by the Rev. J. Pearse, in the *Sunday Magazine*, which also contains a paper entitled "A Thousand Miles up the Irrawaddy," by the Rev. W. R. Winston. *Chambers's Journal* contains, as usual, a number of short and popular articles on more or less scientific subjects. Among those we note a description of some remarkable artesian wells, and a paper on the utilisation of waste products. Mr. Grant Allen writes pleasantly on "The Night Jar," in the *English Illustrated*, and Colonel Howard Vincent describes the scientific measurement and identification of criminals.

In addition to the magazines mentioned in the foregoing, we have received the *Fortnightly*, *Longman's*, and the *Humanitarian*, neither of which, however, contain articles that call for comment here. The first number of the *Phonographic Quarterly Review* has also been sent to us. The *Review* is edited by Mr. T. Allen Reed, and it bids fair to take a permanent stand among phonographic literature. Some of the articles have been furnished by phonographers, and others by well-known writers, the writings of the latter having been transcribed. The editor evidently recognises the importance of a knowledge of science to the shorthand writer of the present day, for among the articles we note "The Native Tribes of East Africa," by Dr. J. W. Gregory; "Experiences of a Naturalist," by Dr. A. S. Murray; "The Myths of the Unicorn and the Griffin," by Sir Henry Howorth; and "The Formation of Flints," by Canon Bonney. The publication of articles of this kind will help on the time when scientific lectures will be reported without being caricatured.

MEASUREMENTS OF PRECISION.[1]

MORE than two thousand years ago there lived in the far East a philosopher who established his claim to the possession of a good measure of both wisdom and wit, when he wrote: "Avoid even the appearance of evil: do not stop to tie your shoe in the melon patch of an enemy."

Suppressing the humour but not the sentiment of the Oriental teacher, it is easy to see that Confucius meant to impress upon his followers the importance of taking care that, even in the performance of trivial acts, the time and place should be such as would give rise to no suspicions as to motive or design.

I am honoured by being permitted the freedom of your academic groves to-day. I realise that the opportunity of defending a theme under such circumstances is not to be lightly esteemed, and I wish, in the beginning, to make terms with everybody, by declaring that in bringing before you a proposition so simple as to need no argument, I am innocent of ulterior motive or deep design.

My desire to give formal expression to this proposition grows out of the frequency with which it has presented itself in the course of official duties during the past few years.

I wish to consider "Precise Measurement" as one of the agencies through which man has advanced from a condition of savagery to his present state; and the metrology of any age as an exponent of the civilisation of that age.

The brief time during which I can venture to ask your attention to this subject fortunately releases me from all obligations to consider literary excellence or rhetorical ornamentation, and compels me even to deviate in some degree from the logical order of presentation. It is safe, however, to take liberties with an audience so largely composed of those who are not only familiar with the facts to be presented, but who are accustomed to arrange, digest, and put in orderly sequence materials which are found in a more or less chaotic condition.

The first form of measurement to which primitive man resorted was undoubtedly simple enumeration. In narration or barter the number of units in a group was alone considered, regardless of differences among individuals. The recognition

[1] An address delivered at the Johns Hopkins University, Baltimore, by Prof. T. C. Mendenhall.

of the fact that one quantity is greater or less than another is not measurement. Measurement implies the ability to represent numerically, so that ratios can be accurately expressed. Among primitive races measurement by enumeraton is very restricted. Tribes bordering on savagery at the present time are often found to be unable to enumerate beyond three or four. This statement is quite positively made by competent authorities, in spite of the fact that the ability to enumerate the number of fingers on at least one hand would appear to be necessary to even the lowest order of intelligence. It is curious to note in this connection that experiment has apparently proved that four is the maximum number of objects whose accurate enumeration is possible *at a single glance* and without *counting*, by the most highly cultivated man.

As man emerges from savagery his powers of enumeration increase. He soon discovers the necessity for units of a higher order which themselves represent a collection, and easily finds such units provided by nature in the groups of fingers on his two hands. Thus the decimal system of arithmetic is invented; not in one place or by one people, but everywhere and whenever man finds that somewhat extensive enumeration is desirable or necessary. It is a singular exception to this general rule, however, that the Greeks failed to invent a decimal arithmetic.

With systems of notation capable of indefinite extension, measurement by enumeration becomes rigorously exact; that is, barring blunders, which can always be discovered and avoided, the number of units in a group, if capable of being counted at all, can be counted with absolute accuracy. Thus, the cash in the Treasury of the United States may be more than a hundred million dollars, that is more than ten thousand million cents, and the exact quantity can be ascertained to a single cent. By simple enumeration, therefore, this quantity of money is measured so accurately that the error cannot be as much as one part in ten thousand millions, and this might be extended in any degree, if only the cash is there to be counted.

At a comparatively early stage, therefore, this kind of measurement was perfected, but there are two systems or methods of measurement derived from it that are worthy of brief comment. The first includes that variety of mensuration in which the numerical value of a magnitude cannot be obtained by simple counting, but is derived by calculation based on rigorously exact relationship. This is of a distinctly higher order than that just considered, and it is only found among highly intelligent people, those, in short, who have cultivated a knowledge of pure mathematics. A very simple illustration is the determination of the area of a triangle when its base and altitude are known. In this and similar cases a rigorously accurate result is attainable when the data are absolutely correct, but simple counting would be impossible. There are cases, however, and these constitute another step along the line in which we are travelling, in which an absolutely accurate evaluation is impossible, but in which any *desirable degree* of accuracy, however high, may be reached. Perhaps the best known example of this is the determination of the circumference of a circle when its diameter is known. The ratio of the former to the latter, which cannot be exactly expressed, has been determined with a degree of approximation by modern computers, which makes it possible to reduce the outstanding error to an inconceivably small quantity. An attempt to illustrate this may not be without interest.

In a display of mathematical genius which has perhaps never been surpassed, Archimedes more than two thousand years ago discovered the first real approximation to the value of this constant. The accuracy of his result may be shown in the fact that if the diameter of a circle be exactly one inch, its circumference as determined by the value of the constant found by Archimedes will not be in error more than the thickness of a human hair. If the value of the constant is more accurately known, it will be possible to compute the circumference of a proportionately larger circle so that the error shall not exceed a hair's-breadth. Let us go at once from the circle one inch in diameter to one having a radius equal to the distance from the earth to the sun and a circumference of nearly 600 millions of miles. It is difficult to form any adequate conception of the enormous stretch of 93 millions of miles which separates the earth from the sun. The immensity of it is in some degree realised on reflecting that if it were possible for a child to extend an arm across this space, and plunge his hand into the white hot layer of the sun from which light is radiated, he might grow to youth, manhood, old age, and unless he lived through the almost unprecedented period of 125 years, death would come before he would feel the pain of burning, so great is the distance through which the sensation must travel. But even this circle, of 600 millions of miles in circumference, is almost immeasurably small in comparison with the one for which we are seeking. Multiply it by a million; a million million; a million, million million; in fact multiply it by a number expressed by the word million repeated 98 times, and we reach a circle of utterly inconceivable dimensions; yet so precisely do we know the ratio of the circumference to the diameter of a circle, that having given the diameter of such a circle, its circumference can be determined within the breadth of a hair. For all ordinary, practical purposes this is sufficient.

A very modern and an extremely important species of measurement involving only enumeration is to be found in the statistical method of treating certain classes of problems in which the object is to follow the fortunes of a group rather than an individual. It has long been advantageously applied to social, political, and economical questions, and within a few years, in the hands of such men as Clerk Maxwell, Boltzmann, and others, it has proved to be a powerful agent in physical investigations.

It depends in great measure on what may be called the principle of the "long run," which is, that phenomena of apparently the most accidental and lawless character will, *in the long run*, occur with regularity and obedience to law, to such an extent as to render their prediction quite possible. At least one great railroad system in this country has so tabulated and investigated all accidents happening to its employés and patrons that it is able to foretell with a good degree of accuracy the number of people who will, during the next year, meet with death on its line; how many will lose a foot, how many an arm, and so on; and its Board of Directors is thus always ready to weigh the cost of a new invention to add to the safety of travel, against the probable damages to be paid for fatal and other injuries which said invention might prevent.

Further argument is unnecessary to show that measurement by enumeration, the first to appear in the evolution of man and his accomplishments, has advanced with man and kept pace with his accomplishments; that it has contributed greatly to his advancement, and that at any given period it may fairly stand as an exponent of his condition.

But in a far greater degree is this true of the second of the two forms of measurement to which men have resorted, namely, that in which a conventional unit embodying the particular quality to be measured is compared to the magnitude to be evaluated. Nearly all operations ordinarily called measurements belong to this class, and its necessity must have followed closely upon the introduction of measurement by enumeration. Of the three fundamental measures, from which it is convenient to derive all others, namely, length, mass and time, the first and last were undoubtedly the earliest to receive attention, and it is more than likely that some rude system of time measurement constituted the earliest contribution to metrology. Nature is lavish in the number and variety of time units which she has furnished man, some of which satisfy the most rigorous demands of modern science. In the early stages of chronometric development the method of enumeration was alone available. By taking the solar day as the unit, counting the number of days in a lunar period furnished the month. The year was similarly obtained, at first from the mere cycle of the seasons, but in a somewhat more advanced stage of development, from more exact observations upon the sun. Before this, there must have existed a demand for the division of the day into smaller units of time. Much ingenuity and often genius of a high order was shown in the invention of chronometric devices. A remarkably clever determination of the angular diameter of the sun was made by the Chaldeans by the use of one of the earliest forms of time-measuring apparatus. At the moment the sun's disk appeared in the eastern horizon a fine stream of water flowing from the bottom of a vessel in which the level was kept constant, was caught in a small cup, into which it was allowed to flow until the lower limb of the sun was visible. The small cup being instantly withdrawn, another much larger receptacle was substituted for it, and into this the small stream fell during all the day and until the sun appeared in the east again on the following morning. It was found that the water in the large vessel was 720 times that in the smaller, from which it appeared that the apparent diameter

of the sun was $\frac{1}{720}$ of the circumference of the heavens, or one-half a degree of arc.

It is impossible here to trace the evolution of time-measuring from the earliest period to the present, and it is unnecessary, because most of the steps are doubtless well known to you all. You are requested to reflect, however, upon the close relation of the various stages of this evolution to the progress of the human race from savagery to enlightenment.

Hardly anything is a more certain and sensitive index of the advancement of a people than the precision required in the time schedule of the ordinary events of life. Improvement in time-measuring instruments, watches and clocks, is in response to a demand for this precision, and not the cause of it, as is sometimes asserted. Watches are now regulated to seconds where formerly minutes were near enough, and the few remaining civilised people among whom the hour has been the smallest division of time in common use, are fast mending their ways in this respect.

Unfortunately in the development of systems of measurement of length and mass, we have not succeeded as well as with the measurement of time. The greater excellence of the latter is unquestionably due to the universality of the fundamental unit, which is everywhere the day. While there have existed some differences among different nations as to the divisions and multiples of this unit, certain natural phenomena have directed all, along nearly the same lines, and at this moment, in all essential particulars, the chronometric systems of nearly all civilised nations are identical. Although not the best that could have been devised had existing knowledge and experience been available in the beginning, the prevailing subdivisions of the time unit are not seriously objectionable, and as they are so nearly universal and so firmly established by long usage, they are almost certain to continue unchanged.

In measures of length and mass or weight, the tendency from the beginning, up to a very recent period, has been, as in the case of time, towards the selection of natural units.

Dimly comprehending the importance and necessity of invariable units of measure, primitive man looked to nature to find the invariable. The nomenclature of every system of measure known bears testimony to the original use of natural units. Of measures of length familiar to all may be mentioned the hand, foot, pace, fathom, cubit, ell and span, all of which are derived from the dimensions of the human body. The inch, as everybody knows, was originally the length of three barley-corns from the middle of the ear, placed end to end. At a later period among some of the Oriental nations the unit of length was the length of a bamboo pipe, which when blown would produce a certain musical pitch. This argues a reckless indifference as to units of length, or an extraordinary power of detecting variation in the pitch of musical tones.

Units of weight or mass also had their origin in natural magnitudes, although in this case much greater difficulty is experienced. Almost the only natural unit of mass that was suggested or used was the mass of a grain of wheat from the middle of the ear, and from this our use of the grain weight of to-day is derived.

But all men are not alike in stature, nor are grains of wheat of great uniformity in dimensions or mass. As might have been anticipated, under such conditions there grew up, not only in different parts of the world, but in different sections of the same country, a variety of systems of weight and measure having no exact relations to each other, or among themselves, and which developed, as intercourse between nations became easier and more general, into one of the greatest calamities ever visited upon mankind. Various efforts were made at various times by various nations, each to improve its own system, but little good resulted up to almost exactly one hundred years ago. At the close of the Revolutionary War the weights, measures and coins in use in this country were almost innumerable in kind. Although mostly inherited from our Anglo-Saxon ancestors, many other European systems had gained a foothold, and considerable diversity in names and values had grown up throughout the colonies. An opportunity was presented at that time which we shall never see again, and which was lost by what one is forced to call the moral cowardice of men in high places. No one appreciated this opportunity more thoroughly than Thomas Jefferson, perhaps the most scholarly man of his time; the patron and friend of science and scientific men.

Jefferson recognised the incongruities of existing systems of weight and measure, but not wishing to depart sensibly from the foot as a unit of length he offered ingenious suggestions for a perfected scheme of linear measurement in which the foot was to be related decimally to the length of a seconds' pendulum and was to be decimally subdivided.

The Constitution of the United States provides that Congress shall have power to coin money, regulate the value thereof, and to fix the standard of weights and measures. At an early day this power was wisely exercised to provide escape from the bondage of the unphilosophical pounds, shillings and pence of the mother country by the establishment of a decimal system of coin ratios, the use of which during the past hundred years has been a greater gain, as compared with the discarded system, than the value of all the money in the country at the time of its adoption.

The second prerogative, that of "fixing a standard of weights and measures," was not at that time and, as a matter of fact, has never yet been exercised by Congress; indeed, considering the great danger which continually existed that when Congress did act it would act wrongly, it is a matter of congratulation that legislation on this important matter has thus far practically gone by default. But the opportunity existing during the early days of our national life was great, for the reason that just at this time there was conceived and perfected on the other side of the Atlantic the most decided, the most important, and the most far-reaching advance in metrology that the world has ever seen.

It had its beginning in the wisdom and foresight of the distinguished Talleyrand, who in 1790, while still a bishop, impressed by the excessive diversity and confusion of the weights and measures then prevailing, proposed to the Assembly of France a scheme for their reformation. Realising that not only national but international reformation was desirable, other nations were invited to join in the development and execution of this magnificent scheme. The co-operation of the Royal Society of London and of the English Government was sought, but unfortunately the English were not then in the mood for giving support to the French.

For the preliminary steps, looking to the determination of the value of the fundamental units and their relation to each other, a committee of the French Academy, including the most eminent mathematicians of Europe, was appointed, among its members being Borda, Lagrange, Laplace and Condorcet. Others engaged in the various measurements necessary to this determination were Lavoisier, Coulomb and Delambre.

Throughout the stormy scenes that accompanied the great political and social changes which occurred in France during the last decade of the eighteenth century, these noble scholars steadfastly pursued the problem upon the solution of which they had set out. At one time Borda, Lavoisier, Laplace, Coulomb and Delambre were dismissed from this public service by Robespierre's Committee of Safety, because their political views were suspected of being not quite in harmony with those of the aggressive party in power. (That was a hundred years ago.) But Robespierre was ambitious as well as cruel, and the project was afterwards allowed to go on. Finally, on June 22, 1799, the two new perfected standards—a metre, the unit of length, made of platinum, and a kilogramme, the unit of mass, of the same metal, were presented with great solemnity at the bar of both houses of the National Assembly of France by the celebrated Laplace, who addressed the assembled legislators; and on the same day the two standards were deposited in the archives of France, destined to be, a century later, the accepted units of measure of more than half of the civilised world, and eventually to become universal. In a report filed just seventy-three years ago to-day, John Quincy Adams, then Secretary of State, says of this event: "The spectacle is at once so rare and so sublime . . . that not to pause for a moment, were it even from occupations not essentially connected with it, to enjoy the contemplation of a scene so honourable to the character and capacities of our species, would argue a want of sensibility to appreciate its worth." "This scene," he says, "formed an epoch in the history of man, and an example and an admonition to the legislators of every nation, and of all after-times."

Just one hundred years ago, in 1794, copies of the preliminary metric standards were sent to this country, and our Government was urged to join in this memorable undertaking. Then, and during the thirty years following, the question of our adopting a system of weights and measures in harmony with our

admirable monetary system was much agitated; but the counsel of the timid prevailed, and the wretched system which we had inherited mainly from England, but which is not in harmony with the English, was allowed to fasten itself upon the industrial interests of the country. The report on the subject by John Quincy Adams, already referred to, is a monument of exhaustive research and philosophical discussion. Nowhere is the decimal system praised so highly as in this report. In it he says of this system that, "considered merely as a labour-saving machine, it is a new power, offered to man, incomparably greater than that which he has acquired by the new agency which he has given to steam. It is in design the greatest *invention* of human ingenuity, since that of printing." This is high praise, and it is difficult to understand how the author of this and much more like it, could lack the courage to recommend that his country should at once put itself in the way of sharing the benefits of so remarkable a reformation. The spirit of conservatism, which came from his ancestors along with the yard and the pound, led him to advise that it was better to await the action of other nations, especially Great Britain.

At the close of the last century, in different parts of the world, the word *pound* was applied to 391 different units of weight, and the word foot to 292 different units of length. Not only were no two of these identical, but in only a few cases were their relative values known with anything like precision. In the wonderful march of the nineteenth century, most of these have been swept away; until now, of the enlightened nations of the earth, only the English-speaking people cling to what Lord Kelvin has so felicitously characterised as our "brain-wearying and intellect-wasting system of weights and measures."

I must now return to a very brief consideration of the indirect influence of precise measurement upon the welfare of man. Thus far the development of exact standards has been considered in relation to man's convenience, as facilitating the transaction of business, by diminishing the uncertainty and labour involved in commerce and trade. But indirectly it has been even more powerful. The use of correct standards of weight and measure has been regarded from the beginning as necessary to and indicative of integrity and fair dealing, among nations as well as individuals. Ultimate standards of reference, even in the earliest history of metrology, were carefully guarded and usually considered a part of the paraphernalia or accessories of the king or ruler. Although these standards were, until a comparatively recent period, very rude in their construction, they represented in a large measure the integrity of the nation, and to depart from or modify them was regarded as akin to a crime. According to Josephus, when Cain had settled in the land of Nod, and built a city, he invented weights and measures. In the law as given to Moses it is declared, "Thou shalt not have in thine house divers measures, a great and a small." The renowned Chinese Emperor, Yeo, who flourished 4000 years ago, kept the weights and measures which were used in the markets in a part of his own palace. In many countries standards were deposited in temples, and priests were their custodians. One of the principal objects sought to be secured by the Magna Charta was uniformity of weights and measures throughout the kingdom, and the one small spot in the world to-day whose neutrality is secured by the joint agreement of all civilised nations, including even the United States and Great Britain, is a bit of land near Paris, where stands the building in which the international prototype metre and kilogramme are preserved.

But in a far greater degree has precise measurement influenced the character, condition and destiny of man through its relation to the development of modern science. Volumes might be written about this, although not much is necessary before an audience to many of whom it is almost a daily lesson, and before another, smaller, audience of those who have contributed so largely during the past quarter of a century to the advancement of science and the improvement of the art of measuring.

Precision in measures demands and produces precision in language, and exact language makes exact thinking possible.

One cannot but admire the genius which enabled some of the philosophers of a few centuries ago to triumph over the obstacles growing out of the lack of exactness both in language and experiment. When Newton was converting his theory of the spheroidal form of the earth into established fact, he could only ascertain the possible effect of change of temperature upon the period of a pendulum by means of comparisons of the length of an iron bar when exposed to the sun's rays on a hot summer's day, with its length on a frosty morning in winter. Even in the earlier Transactions of the Royal Society of London, one may find time measured in *misereres* and temperature in inches. In the wonderful progress that has characterised the present age, by which business methods and social life have been well-nigh revolutionised, exact science has been the dominant factor. It is impossible here even to mention the many interesting devices by means of which during the last half-century the precision of measurements has been enormously increased. They are to be seen in nearly every laboratory, and are familiar to you all. Their invention has made possible many brilliant and useful discoveries in science, and it is gratifying to know that on this line our own country has been and is well to the front. Many proofs of this might be given, but among the most notable contributions of modern times to the science and art of delicate and precise measurement, one cannot fail to note the splendid work of Rowland in his measurement of light wave-lengths, of Langley in his solar researches, and of Michelson in his determination of the metre in terms of the ether vibration. The glory of the nineteenth century is exact experiment and honest logic, and precision in measurement has done much to make both possible.

In the matter of the metrology of the affairs of daily life, however, it is humiliating to confess that we are still skulking in the rear. Our sixty millions of intelligent citizens are far less intelligent, and less fit for the responsibilities that rest upon them, than they might be, were they not continually wearying their brains and wasting their intellects in constant struggle with the difficulties inherent in the system of metrology to which we so blindly cling. I yield to no one in my appreciation of the accurate learning and profound scholarship of the gentlemen of the Faculty of the institution before which I have the honour of appearing to-day, but I unhesitatingly affirm that not one of them, not even all of them together, can correctly set forth the system of weights and measures in common use at the present time in this country. Let us hope that this burden will be lifted in the near future, and that the pound and yard with their innumerable and irrational derivatives, relics of the dawn of civilisation, will be replaced by the beautifully simple kilogramme and metre. We can then rest with the pleasing assurance that when the next cataclysm shall have passed, and the archæologist of the future shall be burrowing among the ruins of the present age, he will not be misled by the crudeness of our metrology to catalogue us along with earlier civilisations. At best he will exhume much which we could wish to remain for ever buried, but let us hope that the evidence of integrity and simplicity in commercial transactions, of delicacy and precision in scientific investigations, and especially of honest and independent thinking, will be such that he will be compelled to put us down as a race in which, to apply the eloquent words of Buckle, "the greatness of men has no connection with the splendour of their titles, or the dignity of their birth; it is not concerned with their quarterings, their escutcheons, their descents, their dexter-chiefs, their sinister-chiefs, their chevrons, their bends, their azures, their gules, and the other trumperies of their heraldry; but it depends upon the largeness of their minds, the powers of their intellect, and the fulness of their knowledge."

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, October 1.—M. Lœwy in the chair.—The mass of Mercury and the acceleration of the mean movement of Encke's comet, according to the recent work of M. O. Backlund. A note by M. O. Callandreau.—On the automatic transmitter of steering directions, by Lieut. H. Bersier. The alternating current from a Ruhmkorff's coil passes from the pivot of a compass through the aluminium pointer, and leaps from the extremity of this needle to one of six vertical plates placed at intervals round the inside of the compass-box. This alternating current has no effect on the magnet, but serves to work six corresponding relays, and hence to cause the illumination of corresponding signal lamps placed in various parts of a vessel, and to set in motion the steering apparatus. The least deviation from the set course is automatically and immediately corrected in this way. The course is altered by simply rotating

the drum carrying the plates.—A description of a bundle of descending cerebral fibres disappearing in the olivary bodies (cerebro-olivary bundle), by M. Y. Luys.—Influence of low temperatures on the laws of crystallisation, by M. Raoul Pictet. The author shows the essential difference in the manner in which the crystallising body loses heat at the moment of solidification in the two cases where the substance is (1) adiathermanous and (2) diathermanous. All substances become diathermanous below $-70°$, and hence the true temperature of crystallisation is only obtained when the surrounding medium is maintained at a temperature very slightly below the solidifying point. Hence an explanation of the anomalies occurring in determinations of the crystallisation point of such substances as chloroform.—On the development of the latent image in photography by alkaline peroxides, by M. G. A. Le Roy. Aqueous solutions of alkaline peroxides or alkaline solutions of hydroxyl can be used as developers, but are inferior to the ordinary reagents.—Action of hydrogen phosphide on potassammonium and sodammonium, by M. A. Joannis. When hydrogen phosphide is passed into a solution of potassammonium or sodammonium in liquefied ammonia, it is absorbed with the production of the solid white substances PH_2K and PH_2Na. Heat destroys these compounds in accordance with the equation $3PH_2K = 2PH_3 + PK_3$. Water decomposes them with liberation of hydrogen phosphide. Nitrous oxide does not yield any substance corresponding with the salts of hydrazoic acid.—Researches on mercuric picrate, by M. Raoul Varet. The preparation and properties of mercuric picrate are described. Thermal data are given in detail, and from them it is seen that the picrate ranges itself along with the acetate rather than with the other soluble salts, the chloride and cyanide. Picric acid displaces hydrocyanic acid from its potassium combination with disengagement of $+10·7$ Cal., whereas hydrocyanic acid completely replaces picric acid in the mercuric salt with liberation of $+12·2$ Cal.—Action of picric acid and picrates on metallic cyanides. The isopurpurates. A note by M. Raoul Varet. When picric acid can replace hydrocyanic acid in its compounds with evolution of heat, isopurpurates are formed; when, as with the mercuric salt, the hydrocyanic acid replaces picric acid with evolution of heat, isopurpurates are not formed.—The antiseptic properties of the vapours of formaldehyde, by M. A. Trillat. The vapours of formaldehyde, produced by the incomplete combustion of methyl alcohol, have proved very efficacious in destroying germs in sick rooms, and have no action on metals or instruments, and but little action on dyed fabrics.—Observations on flours, by M. Balland.—On the anterior extremity of the dorsal cord in the superior vertebrates, by M. G. Saint-Remy.—Evolution of the sexual elements in the composite Ascidians, by M. Antoine Pizon.—On one of the Chytridineæ parasitic on the vine, by M. A. Prunet.—On the calcareous tuffs of the col de Lautaret (Hautes-Alpes), by M. W. Kilian. From this preliminary study of the Lautaret tuffs, it may be concluded: (1) That these tuffs are relatively recent, their disposition indicating that the present aspect of the surface is much the same as that obtaining at the time of their formation. They are more or less mixed with moraine deposits. (2) The vegetable débris contained in these tuffs, notably the cones and branches of *Pinus sylvestris*, indicate the existence at the epoch of their formation of a forest vegetation which has since abandoned these altitudes.—On the presence of carboniferous earth in the Sahara, by M. F. Foureau.—Thermometric observations on the summit of Ararat, by M. Venukoff. M. Gimmer visited the summit of Ararat on August 16, 1894, and found two thermometers left by M. Pastoukoff the preceding year in a tin-plate box. The maximum registered $+17·25°$ C., the minimum $-40°$ C. Another minimum instrument, attached in the open air to a vertical object, indicated $-38°$ C. At the time of the visit, the temperature of the air in the shade was $+3°$ C.—On an aerostatic ascension effected in Russia, by M. Venukoff.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Complete Poetical Works of Constance Naden (Bickers).—Electric Transmission of Energy: G. Kapp, 4th edition (Whittaker).—Fruit Culture for Profit: C. B. Whitehead (S.P.C.K.).—Our Secret Friends and Foes: Prof. P. F. Frankland, new edition (S.P.C.K.).—Edible and Poisonous Mushrooms: Dr. M. C. Cooke (S.P.C.K.).—The Country Month by Month: Owen and Boulger, October (Bliss).—Alpine Climates for Consumption: Dr. H. J. Hardwicke (Churchill).—What is Heat?: F. Hovenden (Whittingham).—Life in Ancient Egypt: A. Erman, translated by H. M. Tirard (Macmillan).—A Text-Book of Inorganic Chemistry: G. S. Newth (Longmans).—Watts' Dictionary of Chemistry: M. M. P. Muir and H. F. Morley, Vol. 4 (Longmans).—Popular Astronomy: C. Flammarion, translated by J. E. Gore (Chatto).—Visions of the Interior of the Earth, &c: the Prince of Mantua, &c. (Simpkin).—Historical Progress and Ideal Socialism: Prof. J. S. Nicholson (Black).—Lectures on Human and Animal Psychology: W. Wundt, translated by J. E. Creighton and E. B. Titchener (Sonnenschein).—A Laboratory Manual of Physics and Applied Electricity: arranged and edited by Prof. E. L. Nichols, Vol. 2 (Macmillan).—An Elementary Manual of Zoology designed for the use of Forest Officers in India: E. C. Cotes (Calcutta).

PAMPHLETS.—Regeln für die Wissenschaftliche Benennung der Thiere, &c. (Leipzig, Engelmann).—Bahnbestimmung des Kometen 1851 III. (Brorsen): Dr. R. Spitaler (Wien).—Philosophical Transactions of the Royal Society of London: Experimental Investigations on the Effective Temperature of the Sun, made at Daramona, Streete, co. Westmeath: W. E. Wilson and P. L. Gray (K. Paul).—Äussere Einflüsse als Entwicklungsreize: Prof. A. Weismann (Jena, Fischer).—English Institutions and the American Indian: Dr. J. A. James (Baltimore).

SERIALS.—English Illustrated Magazine, October (198 Strand).—Longman's Magazine, October (Longmans).—Century Magazine, October (Unwin).—Chambers's Journal, October (Chambers).—American Naturalist, September (Philadelphia).—Natural History of Plants: Kerner and Oliver, Part 6 (Blackie).—Contemporary Review, October (Isbister).—Humanitarian, October (Hutchinson).—Phonographic Quarterly Review, October (Pitman).—Journal of the Royal Agricultural Society of England, Vol. v. Part 3, No. 19 (Murray).—Journal of the Scottish Meteorological Society, third series, No. x. (Blackwood).—Geographical Journal, October (Stanford).—National Review, October (Arnold).—Natural Science, October (Macmillan).—Fortnightly Review, October (Chapman).—Mind, October (Williams).—Geological Magazine, October (K. Paul).—Journal of the Royal Statistical Society, September (Stanford).—Asclepiad, No. 41, Vol. xi. (Longmans).—Medical Magazine, October (Southwood).—Astronomische Mittheilungen von der Königlichen-Sternwarte zu Göttingen, Dritter Theil (Göttingen).—Journal of the Chemical Society, October (Gurney).—Annals of Scottish Natural History, October (Edinburgh, Douglas). Himmel und Erde, October (Berlin, Paetel).—Science Progress, October (Scientific Press, Ltd.).

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